HMA – The Last 50 Years in Indiana

HMA – The Last 50 Years in Indiana

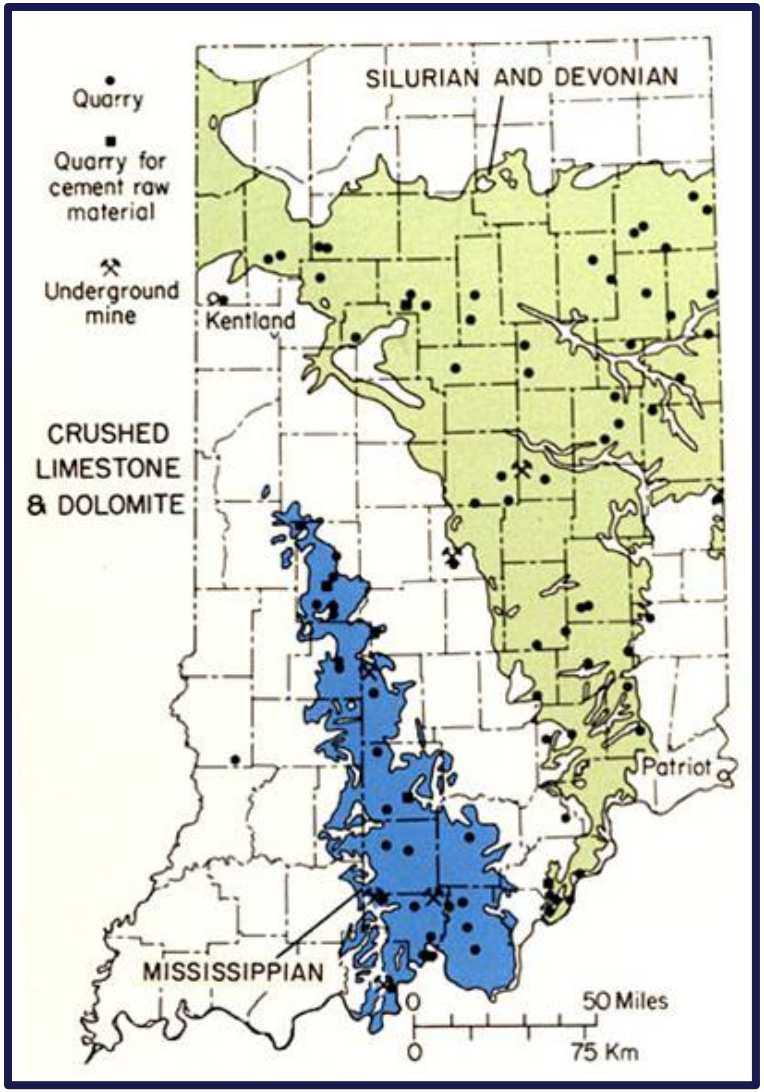
- Materials
- Mix Design
- Sampling
- Testing
- Equipment
- Problems
- Quality Control
- Quality Assurance

Materials - Aggregates

- Certified Sources - 191
  - Stone - 80
  - Sand & Gravel - 50
  - Sand Only - 36
  - Sand, Gr., & St. - 15
  - Slag - 9
  - Recycled - 1

Materials - Stone

- Limestone - all mixtures
- Dolomites - friction resistant surface mixtures
- Sandstone – high ESAL friction resistant mixtures



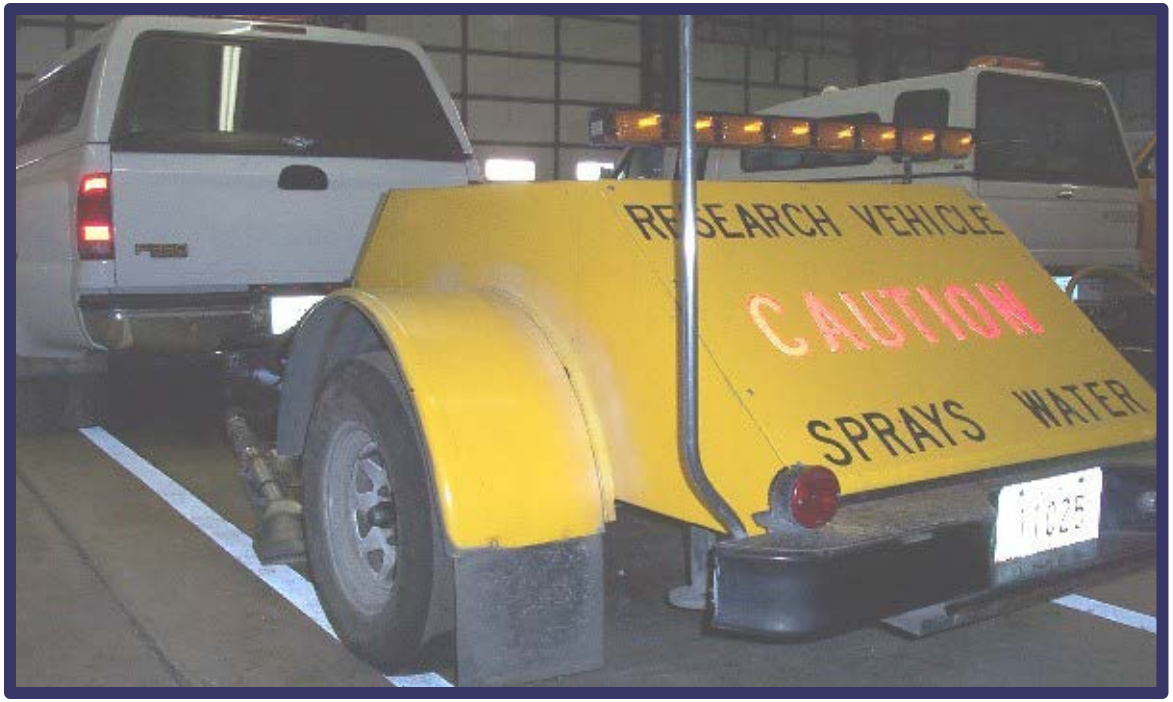
Materials - Stone

- Limestone – Ledge and Production Testing

Materials – Friction Resistance

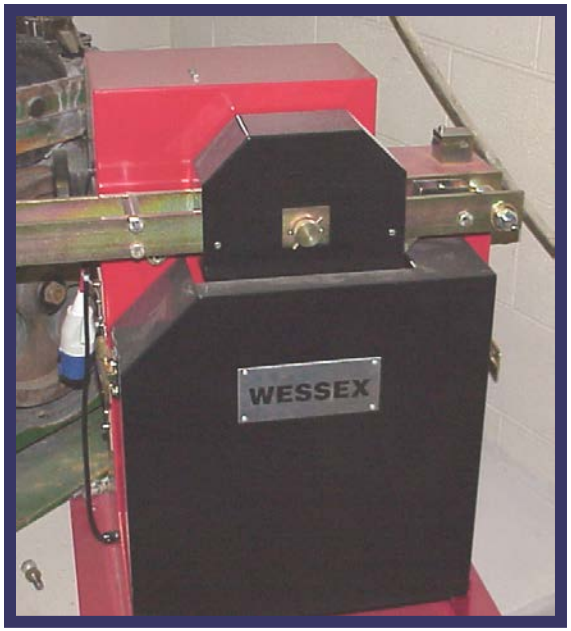
Dolomite - 10.3% Magnesium (1980s)

Materials - Sandstone

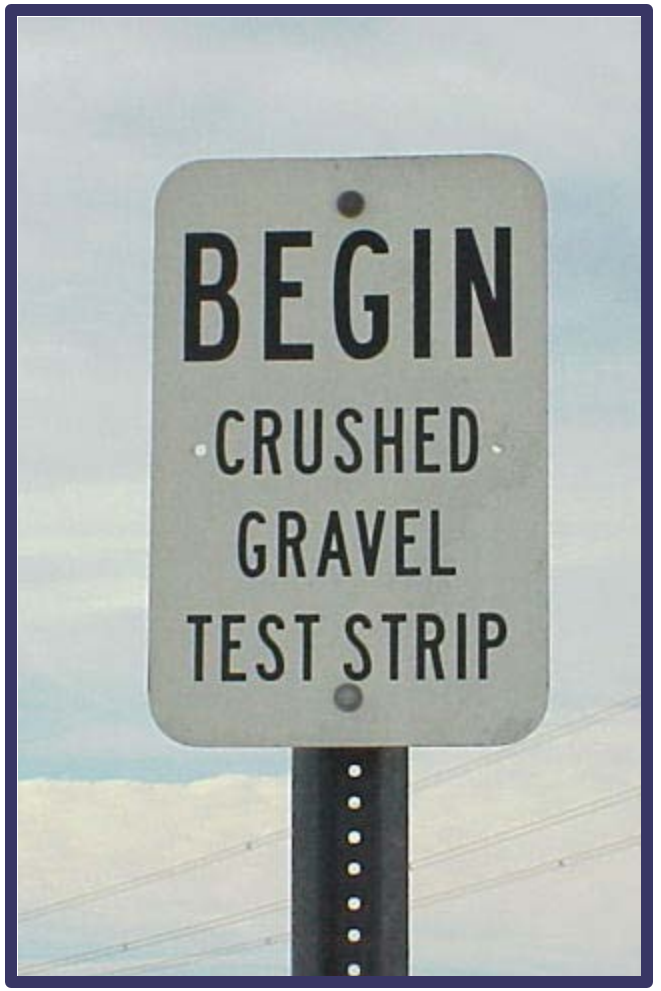


HMA Surface & SMA Surface

Polish Resistant Aggregates
British Polishing Wheel

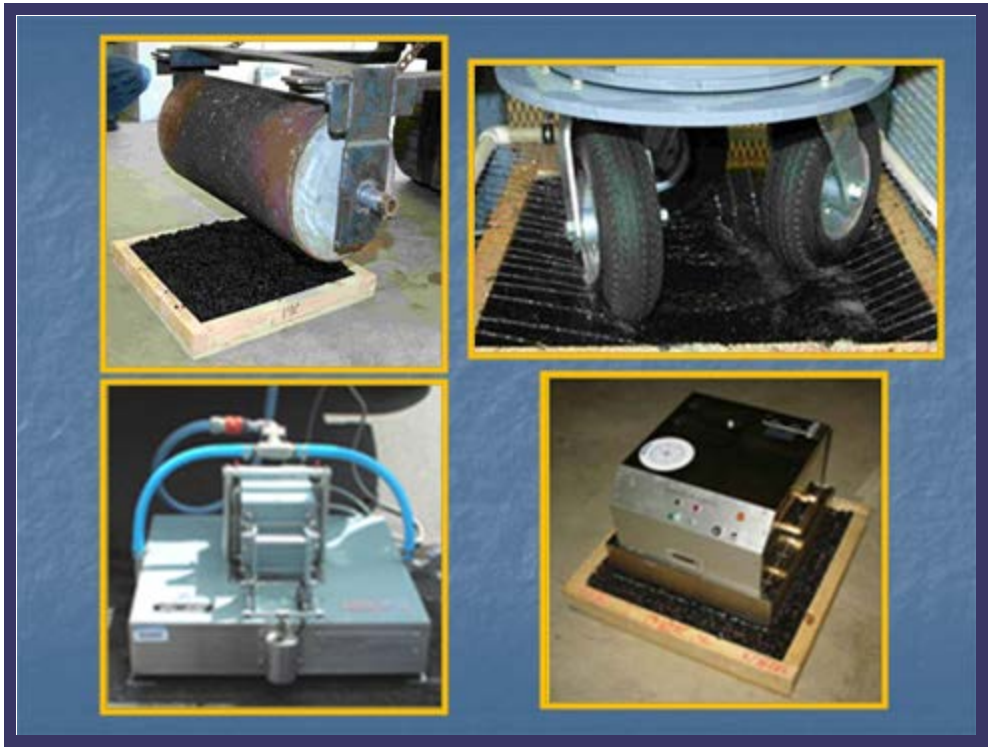


Polish Resistant Aggregates



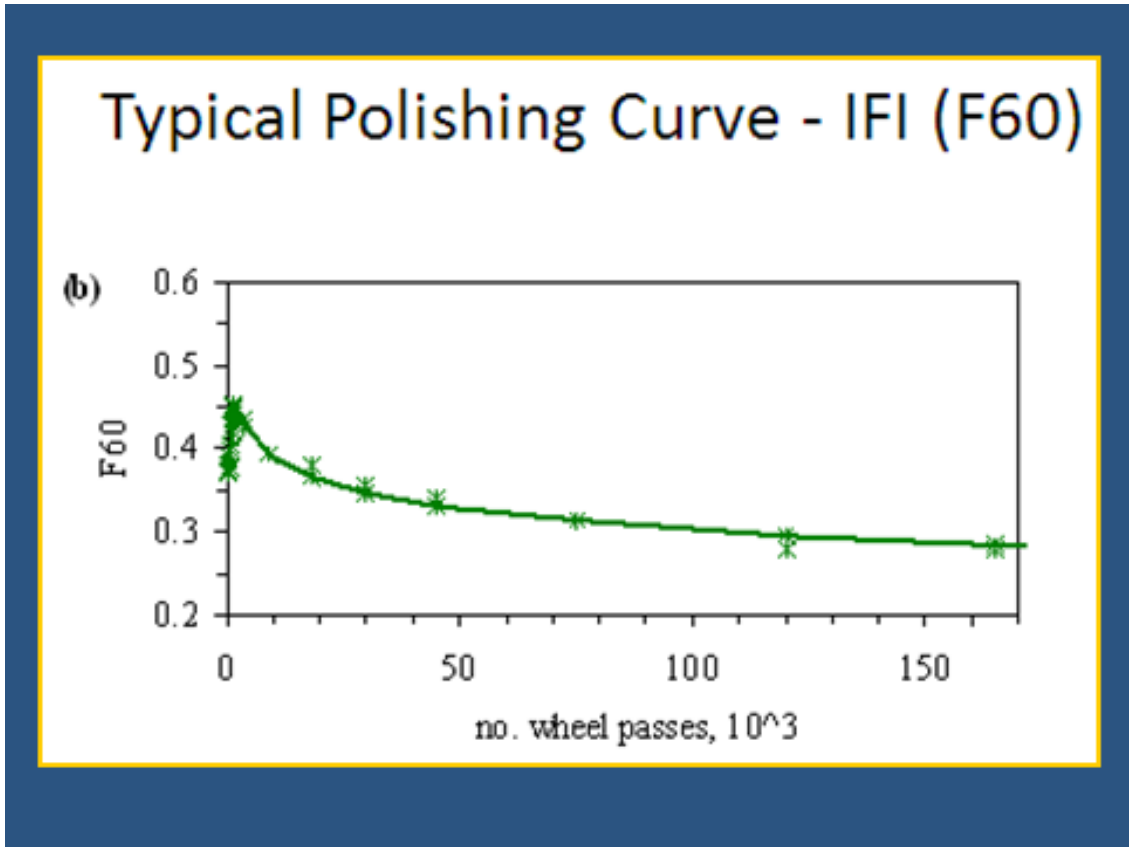
- 2 year evaluation with comparison to test section

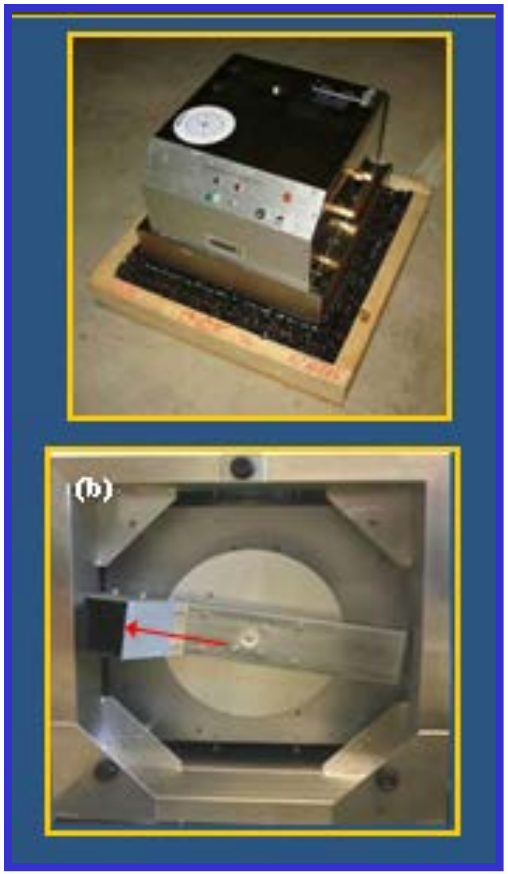
ITM 221 – Acceptance Procedures for HMA Surface Mixture Coarse Aggregate for ESAL ≥ 10,000,000



- Circular Track Polishing Machine
- Circular Track Meter
- Dynamic Friction Tester

Maximizing the Use of Local Aggregates





- 20% of Highly Polishing Aggregate

Abrasion – Stone Matrix Asphalt (SMA)

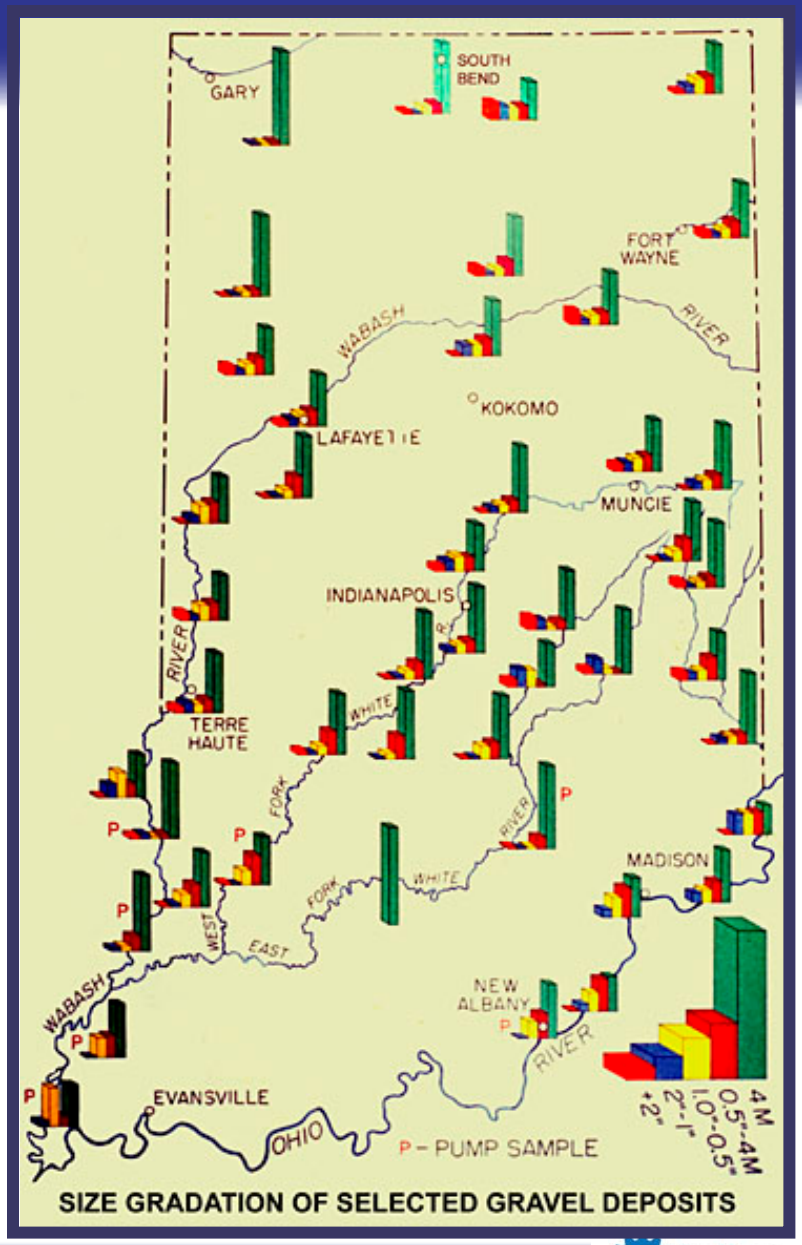
Micro - Deval

Aggregate Degradation

- Gravel Sources - 11
- Stone Sources – 27 / 41 Benches

Materials - Gravel

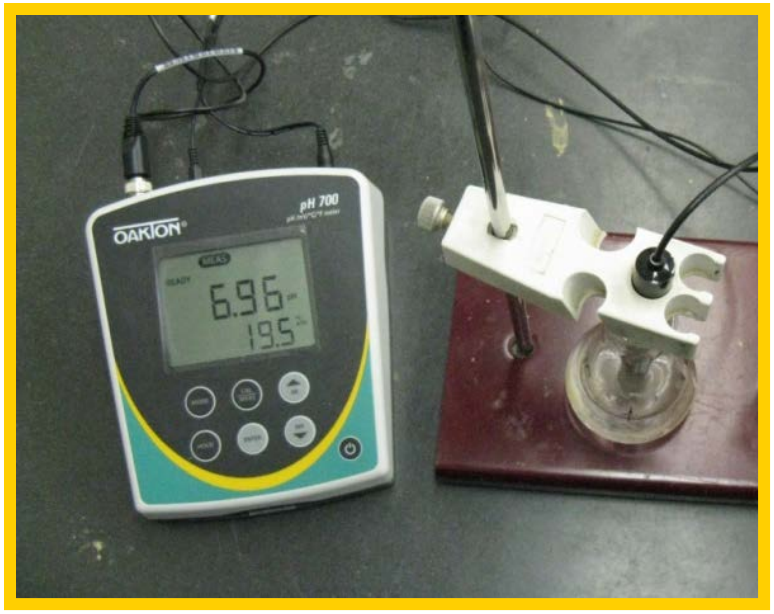
- Sand & Gravel - 50
- Sand Only - 36
- Sand, Gr., & St. - 15

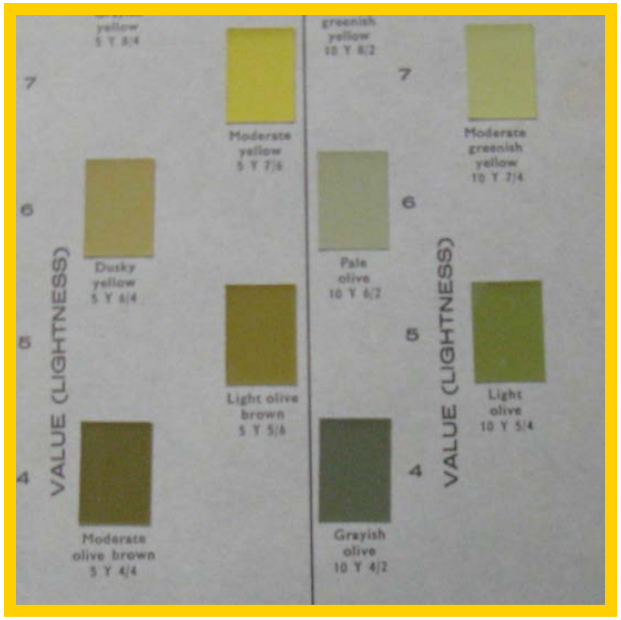


Materials – Blast Furnace Slag

- Variable Specific Gravity
- Surface Area and Absorption
- High Friction Resistant Aggregate

Materials – Blast Furnace Slag





- Leachate – calcium sulfide
- pH and rock color chart requirements

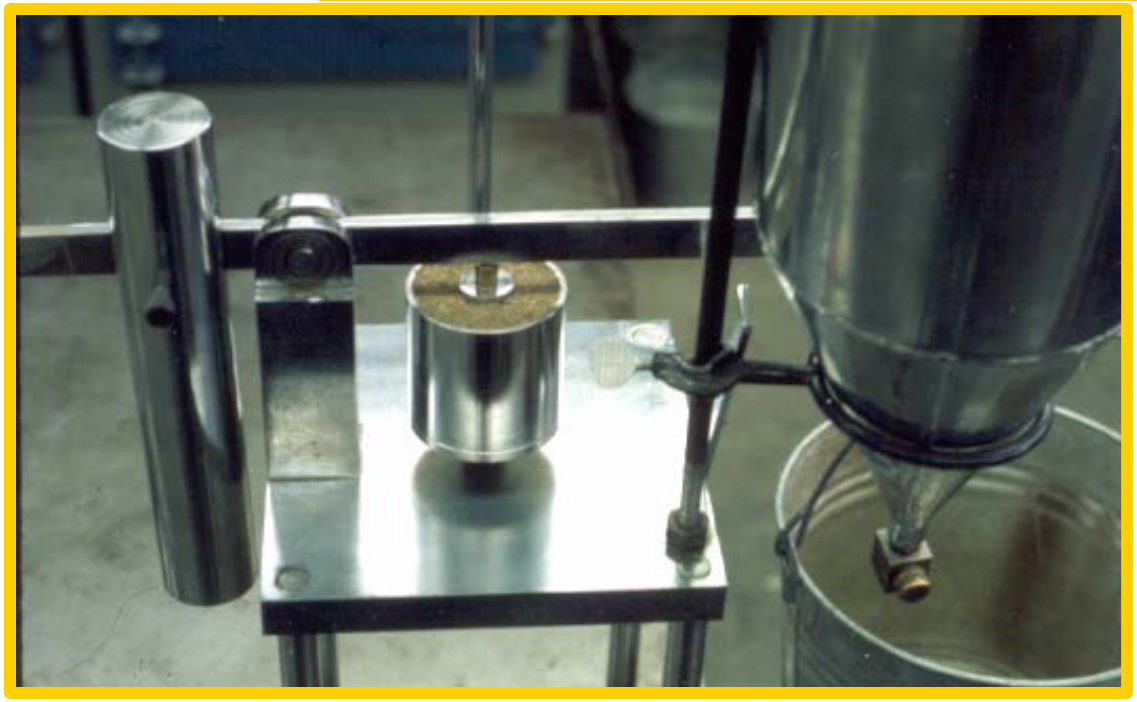
Materials – Steel Furnace Slag

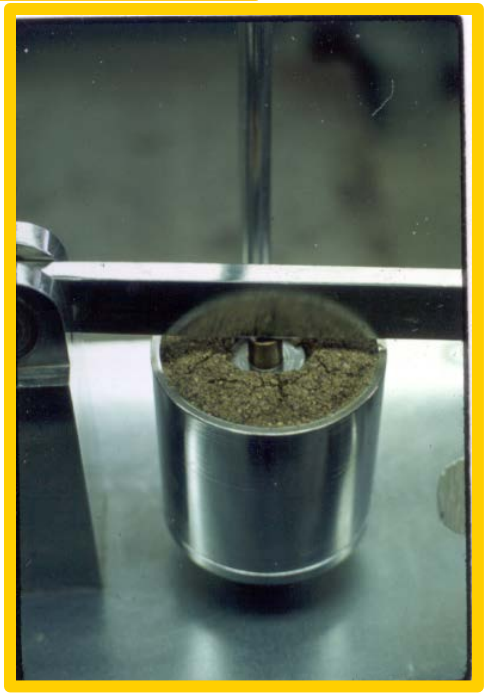
- Limited to aggregate shoulders, HMA or SMA surface ,dumped riprap, and snow and ice abrasives
- Expansion – unaged calcium oxide and magnesium oxide
- Autoclave Test – ITM 219

Materials – Fine Aggregate

Natural Sand – angularity and clay content

Materials – Fine Aggregate



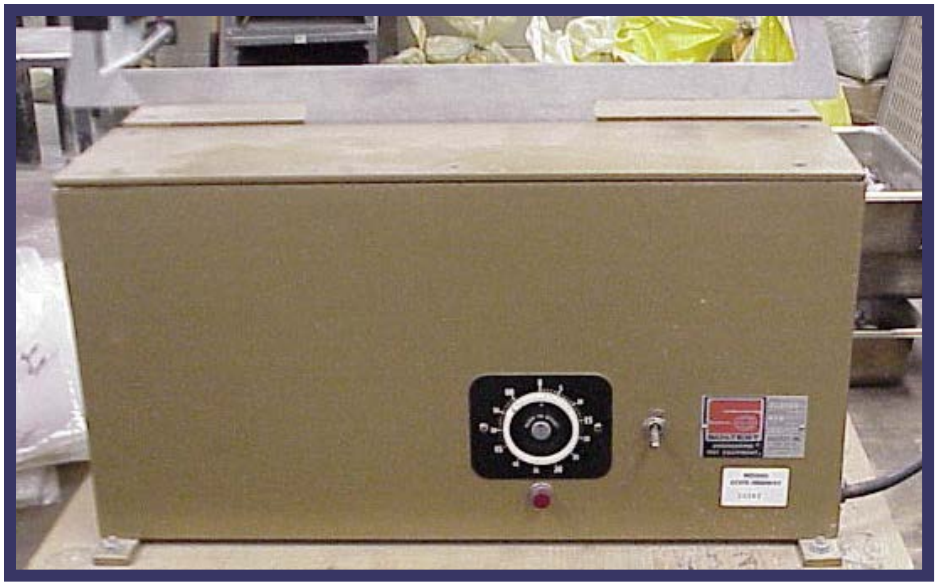


- Florida Bearing Value -- add 0-20 % stone sand to obtain a FBV of 30 for surface mixtures

Materials – Fine Aggregate

FINE AGGREGATE ANGULARITY		
TRAFFIC ESAL	DEPTH FROM SURFACE	
	≤ 4 in.	> 4 in.
< 300,000		
300,000 to < 3,000,000	40	40
3,000,000 to < 10,000,000	45	40
10,000,000 to < 30,000,000	45	40
≥ 30,000,000	45	45

Materials – Fine Aggregate

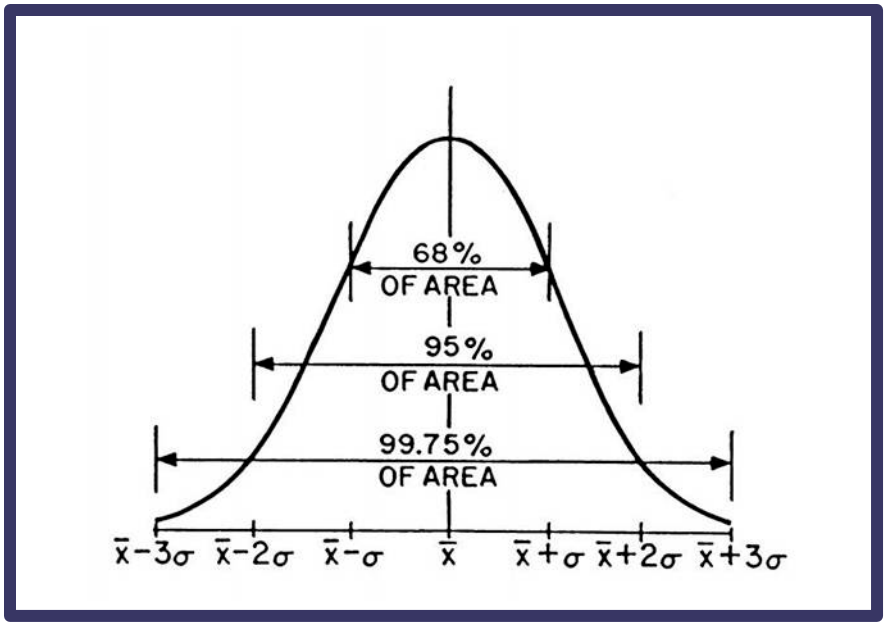


CLAY CONTENT	
TRAFFIC ESAL	SAND EQUIVALENT, MINIMUM
< 300,000	40
300,000 to < 3,000,000	40
3,000,000 to < 10,000,000	45
10,000,000 to < 30,000,000	45
≥ 30,000,000	50

Materials – Aggregate Acceptance

- "Yellow card" system
- Approved each stockpile
- Held up contracts if failing

Materials – Aggregate Acceptance (1994)



- Certified Aggregate Producer Program (CAPP)
- Statistical evaluation of coarse aggregates
- Made Producer responsible for consistency of aggregate gradation
- Ship on demand

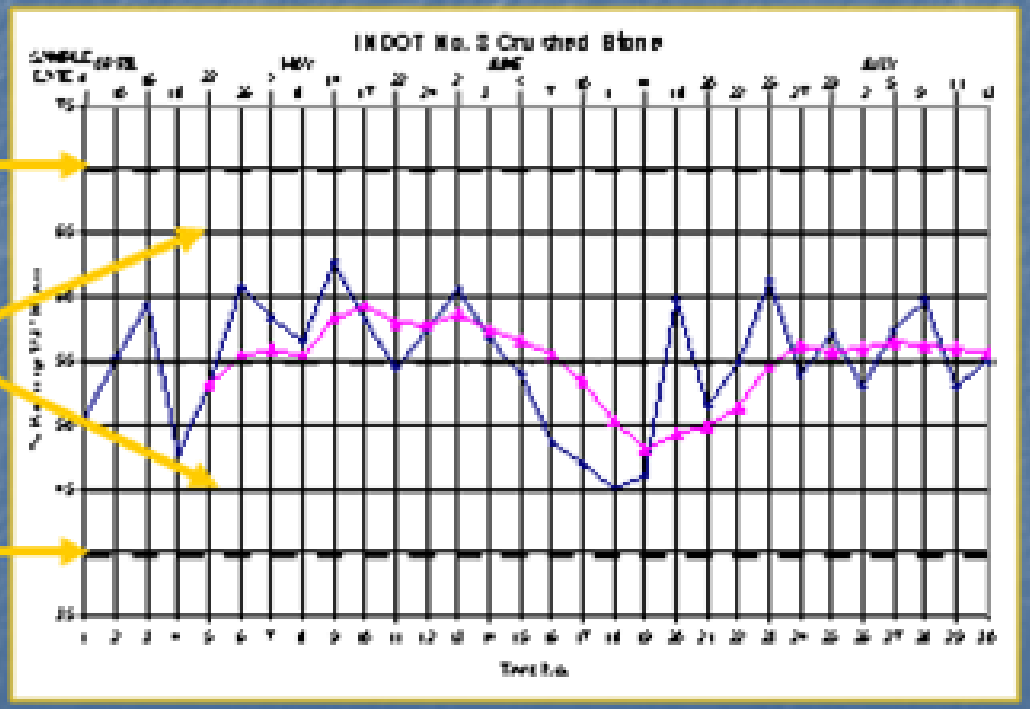
Materials – Aggregate Acceptance (1994)

Control Charts

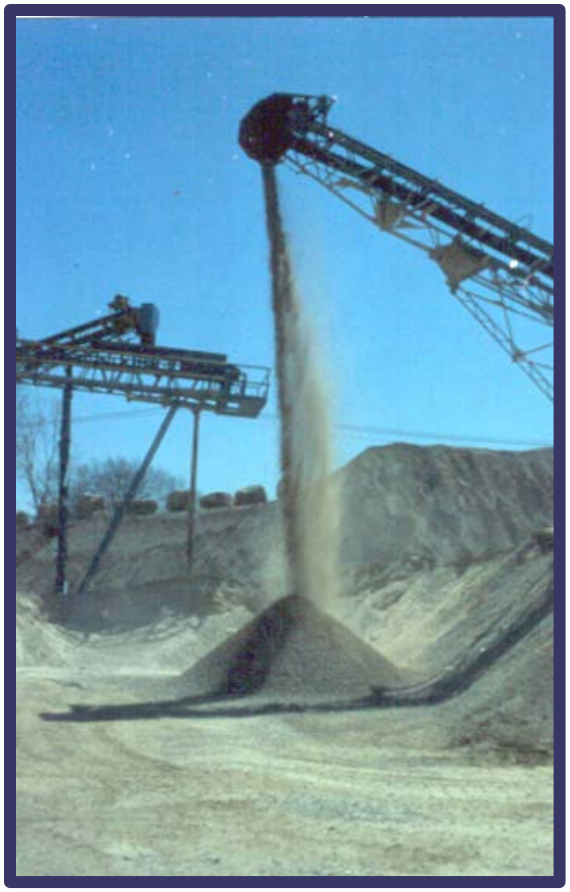
Specification Limit

Control Limits (2σ)

Specification Limit



Materials – Aggregates (CAPP)



- Stockpiling

CAPP - Stockpiling

CAPP – Stockpile Sampling (ITM 207)

CAPP – Sampling Techniques

- Midstream Sampling

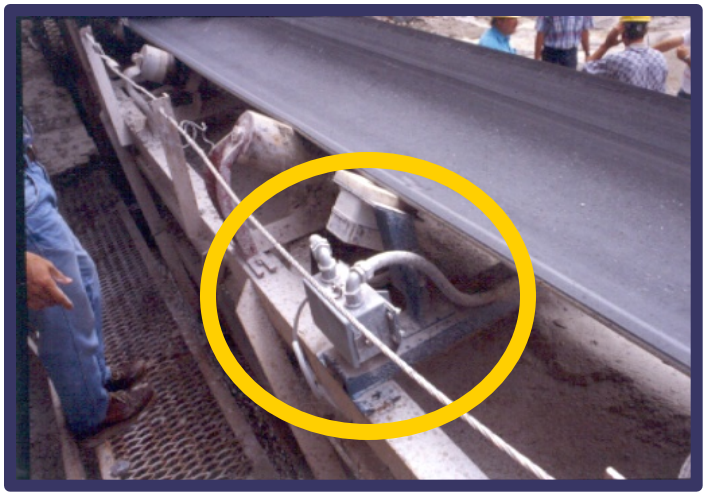
CAPP – Sampling Techniques

- Midstream Sampling

CAPP – Midstream Sampling

CAPP – Midstream Sampling

CAPP – Midstream Sampling



Blended Aggregate Sampling

Blended Aggregate Sampling

CAPP – Gradation Control

CAPP – Testing

Gradation

- Start of Production -- 1/1000t for 5000t with max of 2/day
- Normal Production -- 1/2000t
- Load-Out – 1/8000t

CAPP – Testing

Decant
Each load-out sample

CAPP – Testing

Deleterious
1/week for each size

CAPP – Testing

Crushed Content 1/week for each size

CAPP – Testing

Additional Tests

FA Specific Gravity

CA Specific Gravity

CAPP – Testing

Additional Tests -- FAA

CAPP – Training

- CAPP training - 1994
- ≈ 900 Technicians
- Currently 387 Certified Technicians

Materials – Recycled / Waste Materials

- Air Cooled Blast Furnace Slag
- Ground Granulated Blast Furnace Slag
- Glass
- New Waste Asphalt Shingles
- Reclaimed Asphalt Shingles
- Reclaimed Asphalt Pavement
- Rubber
- Steel Slag
- Wet Bottom Boiler Slag

Materials – Reclaimed Asphalt Pavement

Materials – Reclaimed Asphalt Pavement

- RAP – Heat Transfer Method
- 50 % RAP

Materials - Recycled / Waste Materials

- Many Sizes of RAP
- Binder Replacement

Materials - Recycled / Waste Materials

- Reclaimed Asphalt Shingles (RAS)
- Pre-consumer – 1980s
- Asbestos – Processing
- Available Quantity

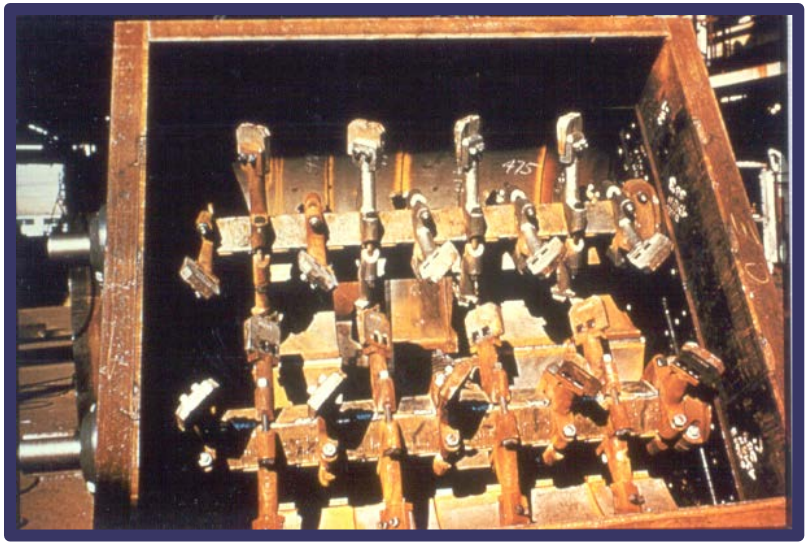
Materials - Recycled / Waste Materials

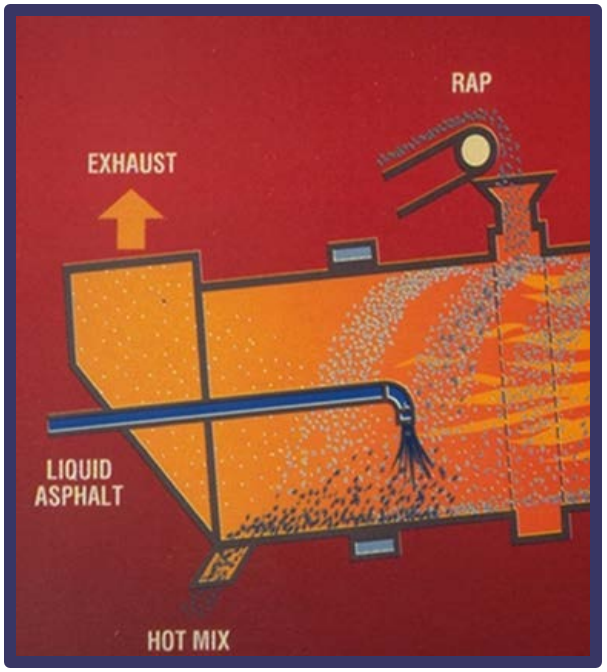
- Post Consumer Shingles
- Deleterious - AASHTO MP 15
- IDEM Legitimate Use Letter

Materials - Rubber

- Wet and Dry Process – 1980s

Materials - Rubber





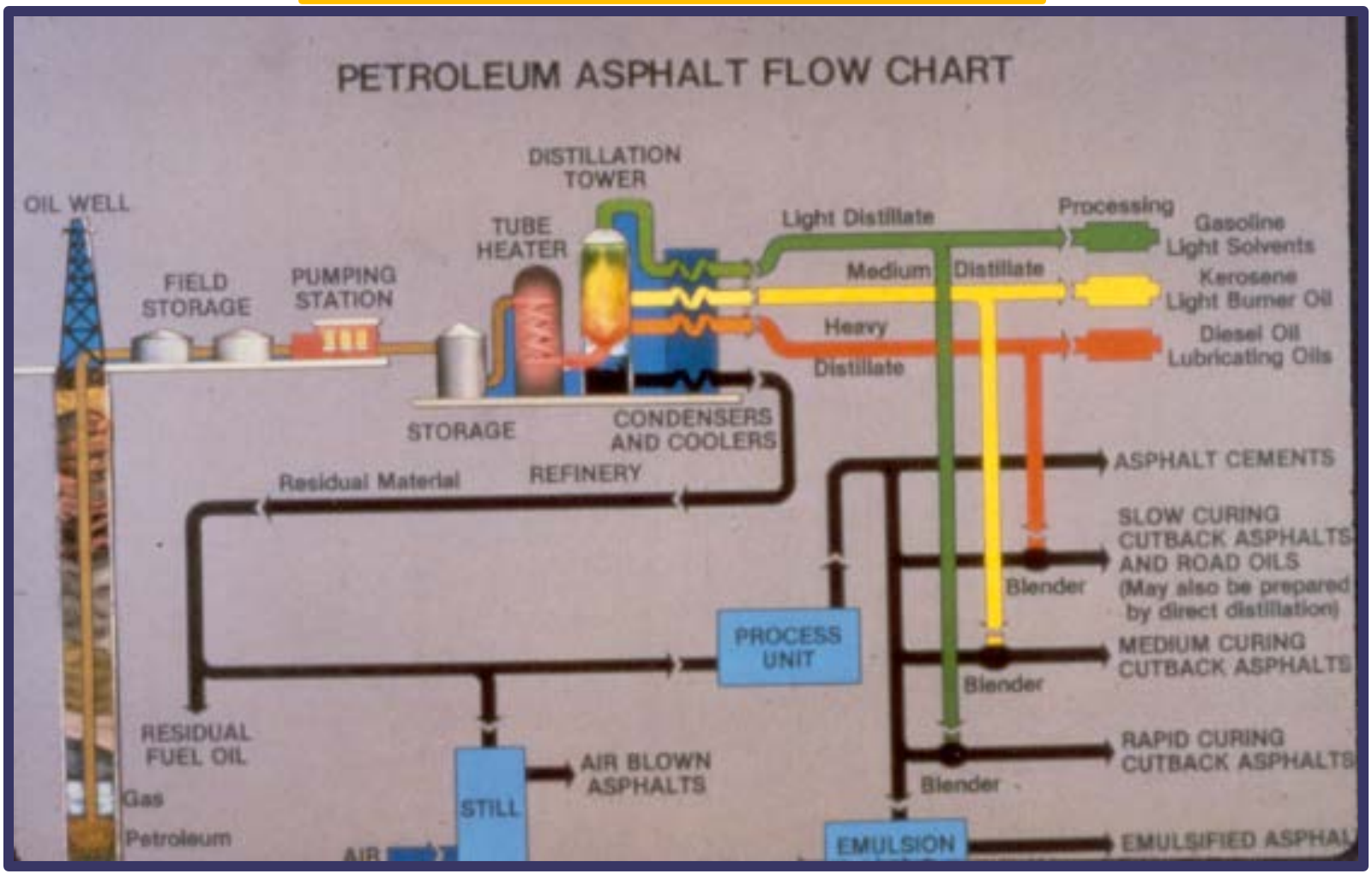
- Dry-Process – added rubber to pugmill
- Wet Process – rubber added to asphalt at plant *

Materials - Rubber

- Pyrolization Plant
- Carbon Black

Materials - Porcelain

Materials - Asphalt



Materials - Asphalt

- Penetration Grades – AP-3, AP-5
- Viscosity Grades – AC-20, AC-40
- PG Grades – PG 58-28, PG 64-22, PG 64-28, PG 70-22, PG 76-22

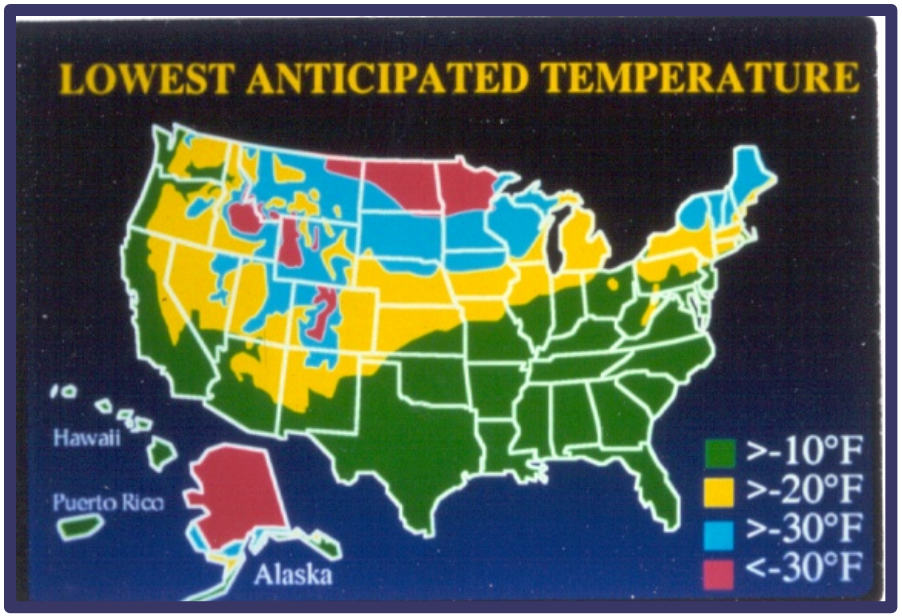
Materials - Asphalt

- **Penetration – Used to control the consistency of asphalts at 77 °F**

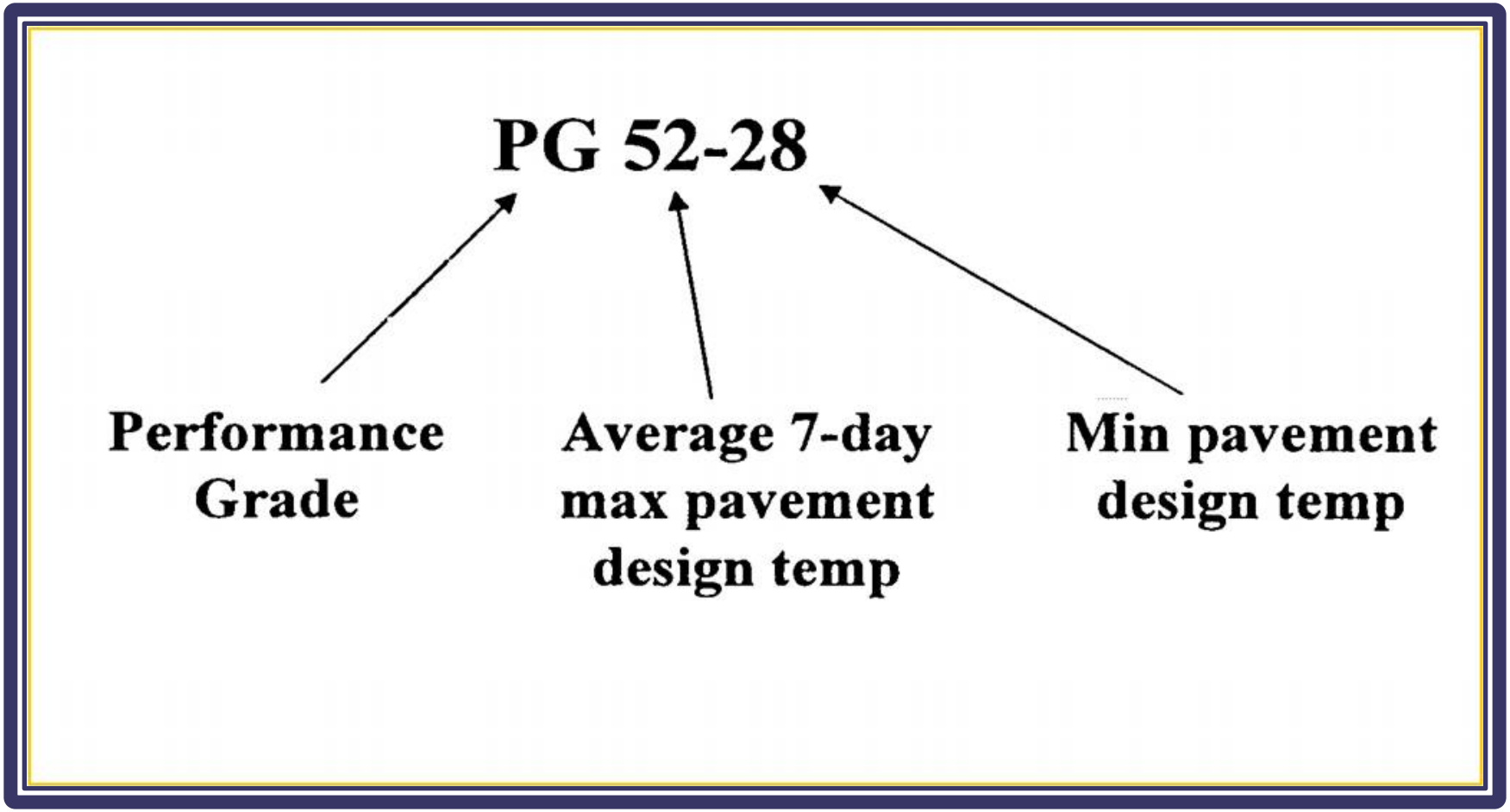
Materials - Asphalt

- Viscosity
- Replace the empirical penetration test with a scientific test
- Measures the consistency at 140°F which better approximates the pavement surface temperature

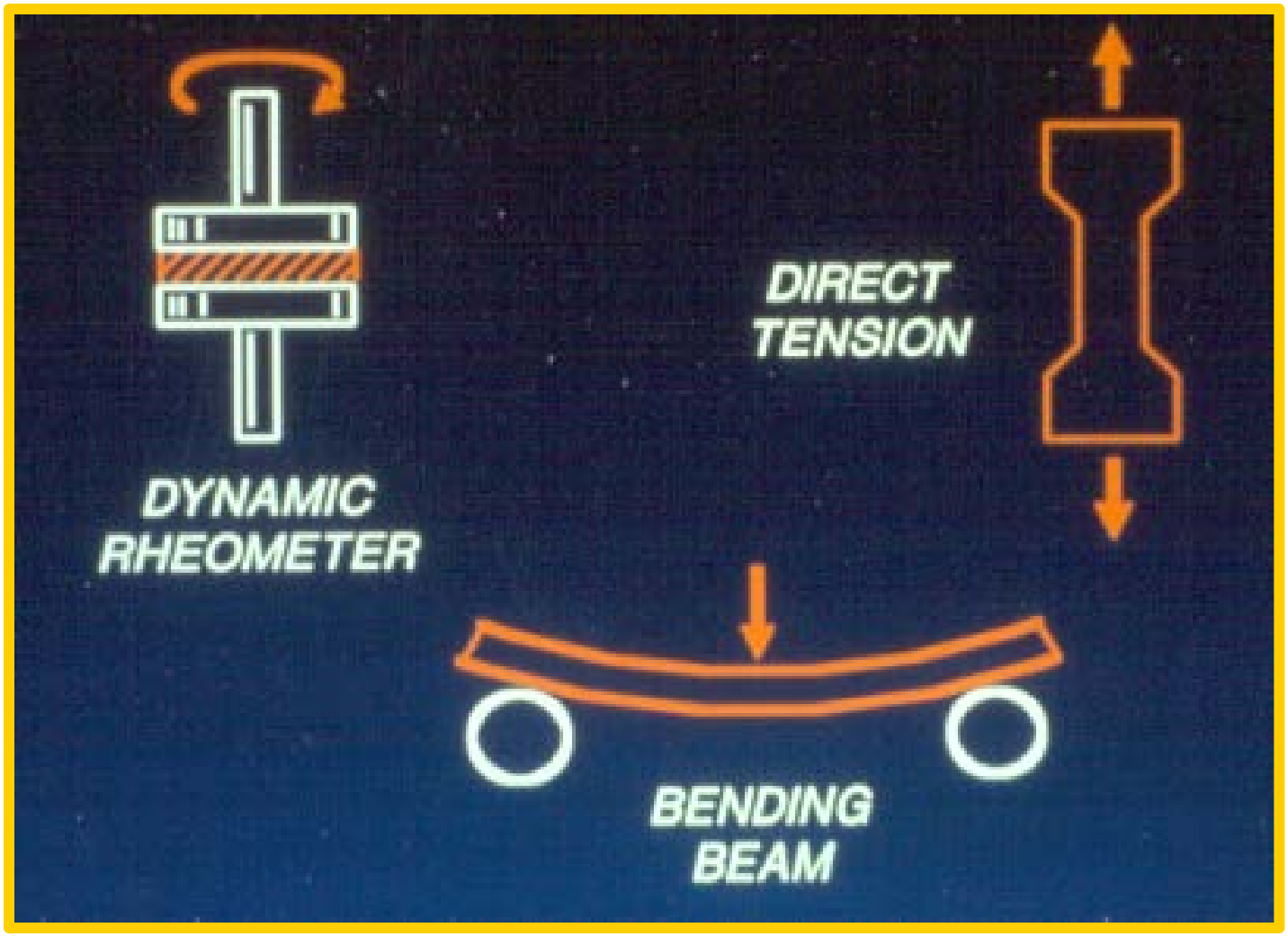
Asphalt – Performance Graded



Performance Graded Binders

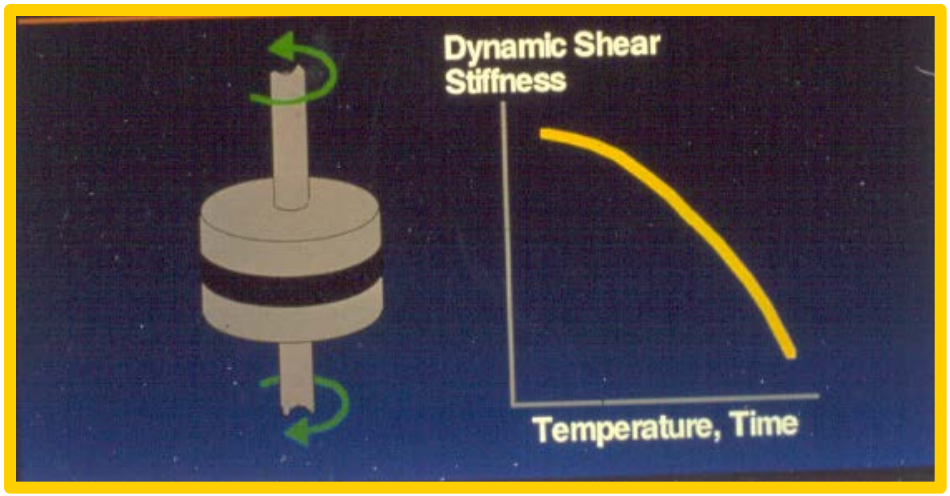


Performance Graded Binders



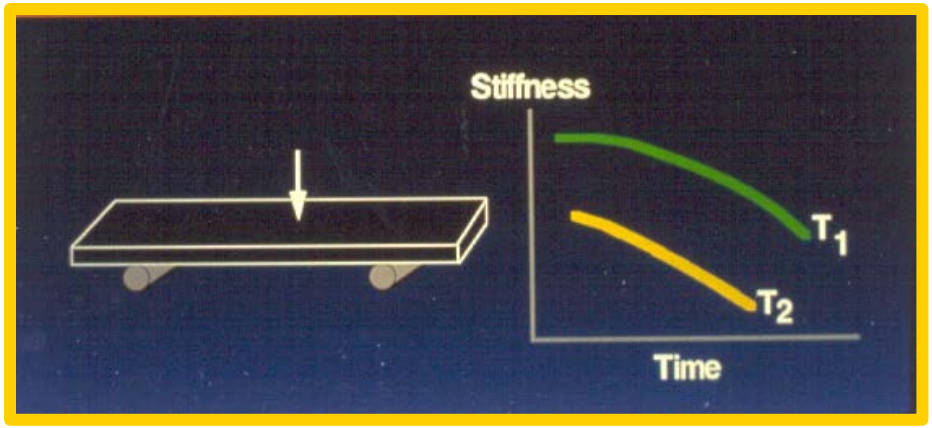
Performance Graded Binders

- Dynamic Shear Rheometer
  - Evaluates binders at upper and intermediate temperatures where rutting and fatigue cracking occur



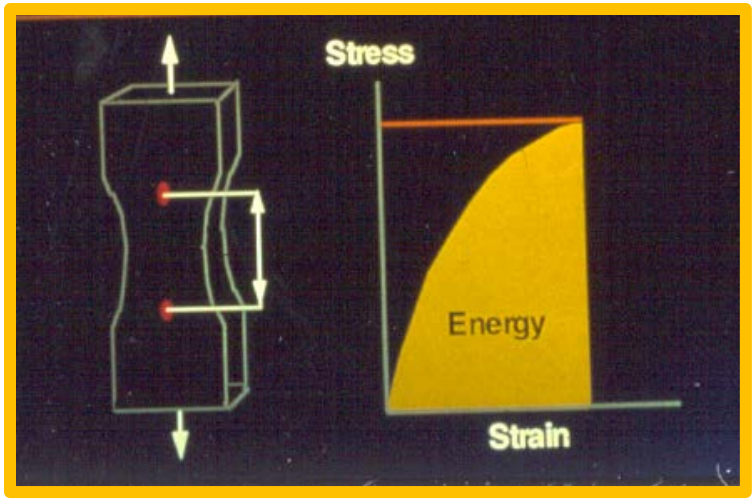
Performance Graded Binders

- Bending Beam
  - Measures low temperature stiffness which relates to thermal cracking



Performance Graded Binders

- Direct Tension
  - Used to estimate the low temperature failure properties of the binder



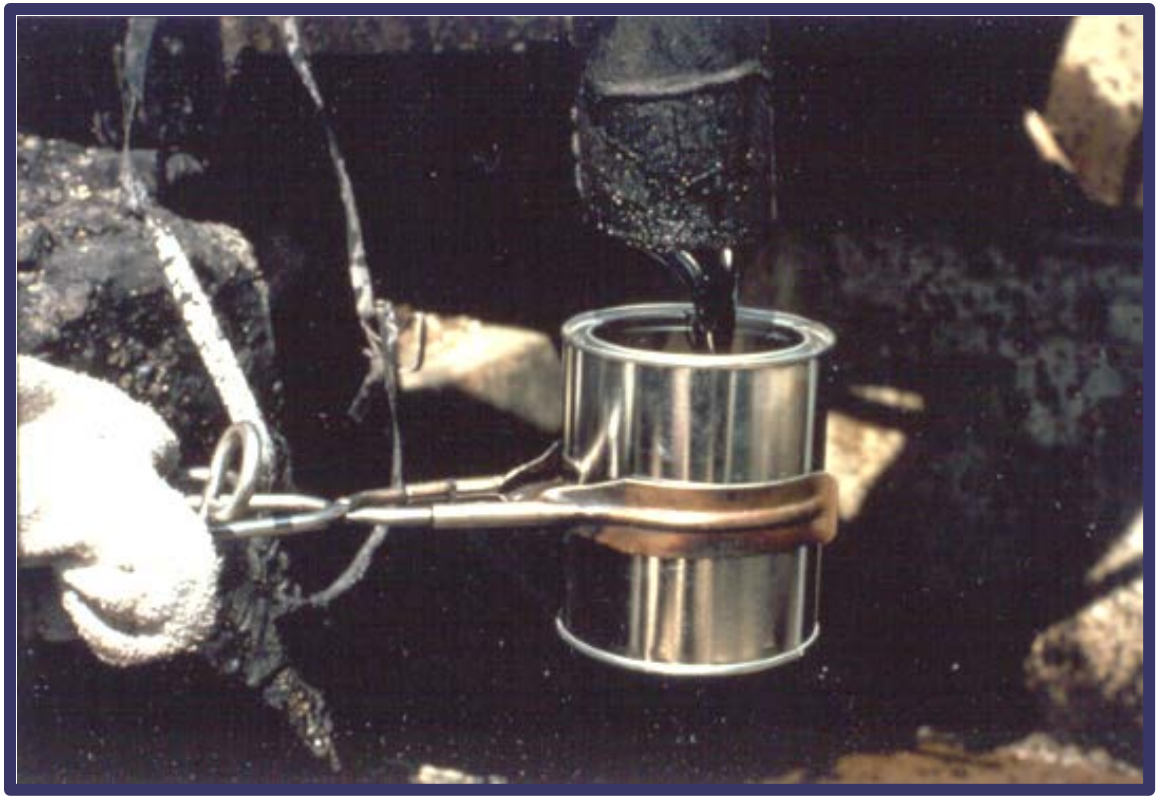
Asphalt – Quality Control

- Asphalt Supplier Certification (ASC) Program (39 sources – 28 fully & 11 partially approved)
  - Materials testing – AASHTO M 320
  - Quality Control Plan
  - Participation in AASHTO AMRL equipment inspection and proficiency sample program

ASC Program

- Supplies a shipping report for each load certifying the PG binder has been manufactured according to the ASC program
- Supplies a Type A certification for PG 58-28 and PG 64-22
- Furnishes instructions with each PG binder on the proper storage and handling of the material

Binder – Quality Assurance

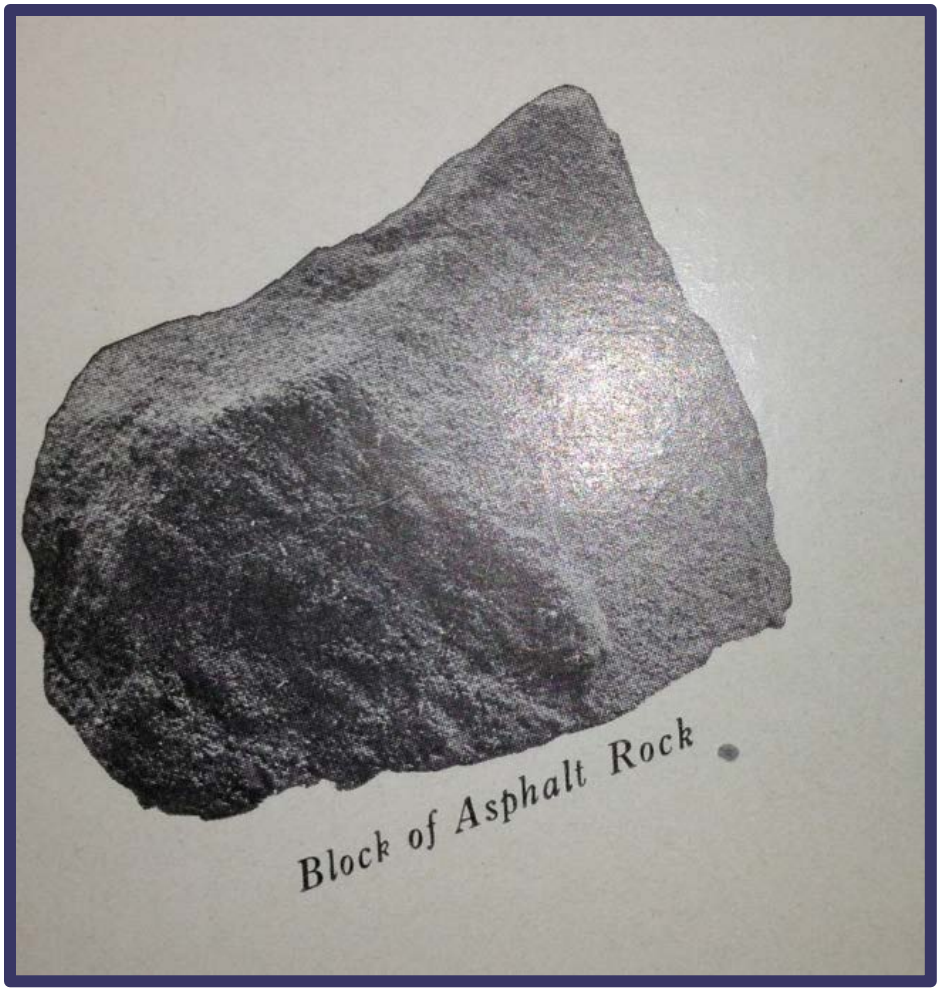


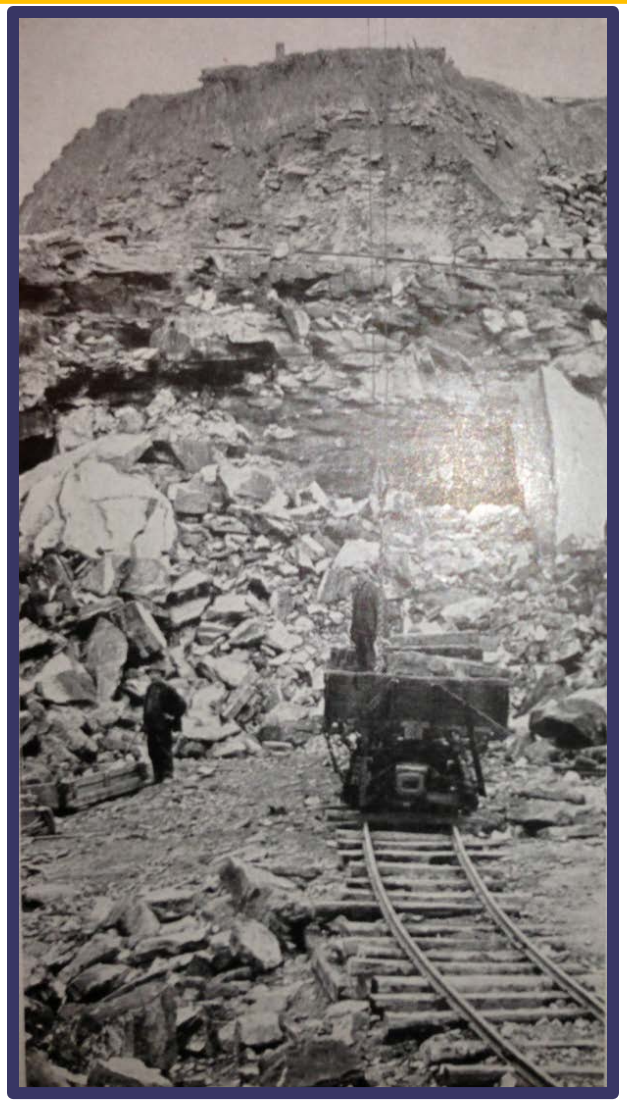
- Acceptance is based on samples taken at the plant except for PG 58-28 and PG 64-22

In-Line Blending

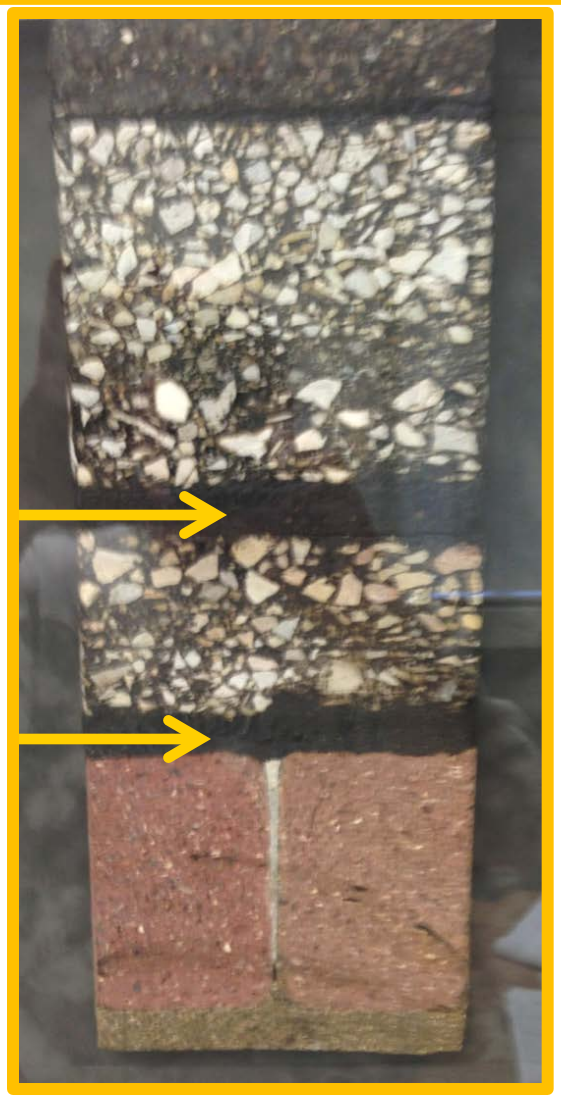
- SBR polymer latex
- PG-58-28 → PG 64-28
- PG 64-22 → PG 70-22

Mixtures – Kentucky Rock Asphalt (Kyrock)





Mixtures – Kentucky Rock Asphalt (Kyrock)



Mixtures

- Dense Graded - standard
- Open Graded – drainage layers & surface mixtures
- Sand Surface – high friction resistant
- Stone Matrix Asphalt – rut resistant surface

Mix Designs - Hveem

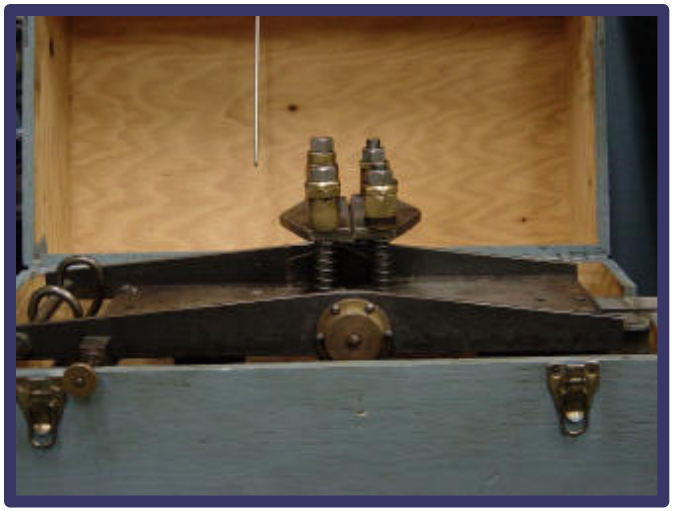
- Kneading Compactor – applies pressure to the specimen through hydraulically operated tamper foot

Mix Designs - Hveem

- Stabilometer – ability to resist shear forces applied by wheel loads

Mix Designs - Hveem

- **Cohesiometer – measured the tensile property of the mixture that was related to a minimum level to prevent raveling of surface mixes**



Mix Designs - Marshall

Developed as method that which could be taken to the field for quality control purposes

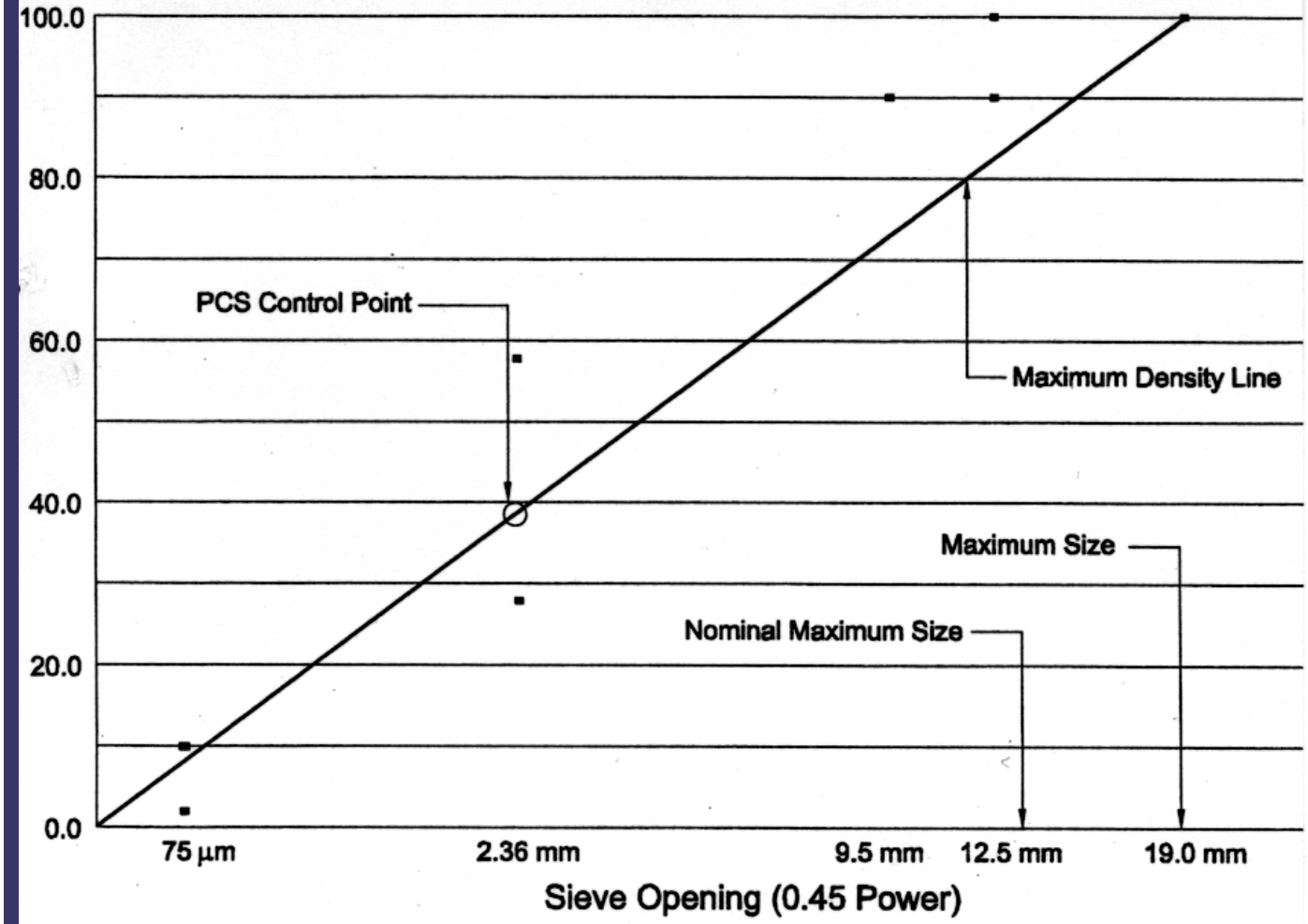
Mix Designs - Marshall

- Started in 1984 as a mix design and quality control procedure

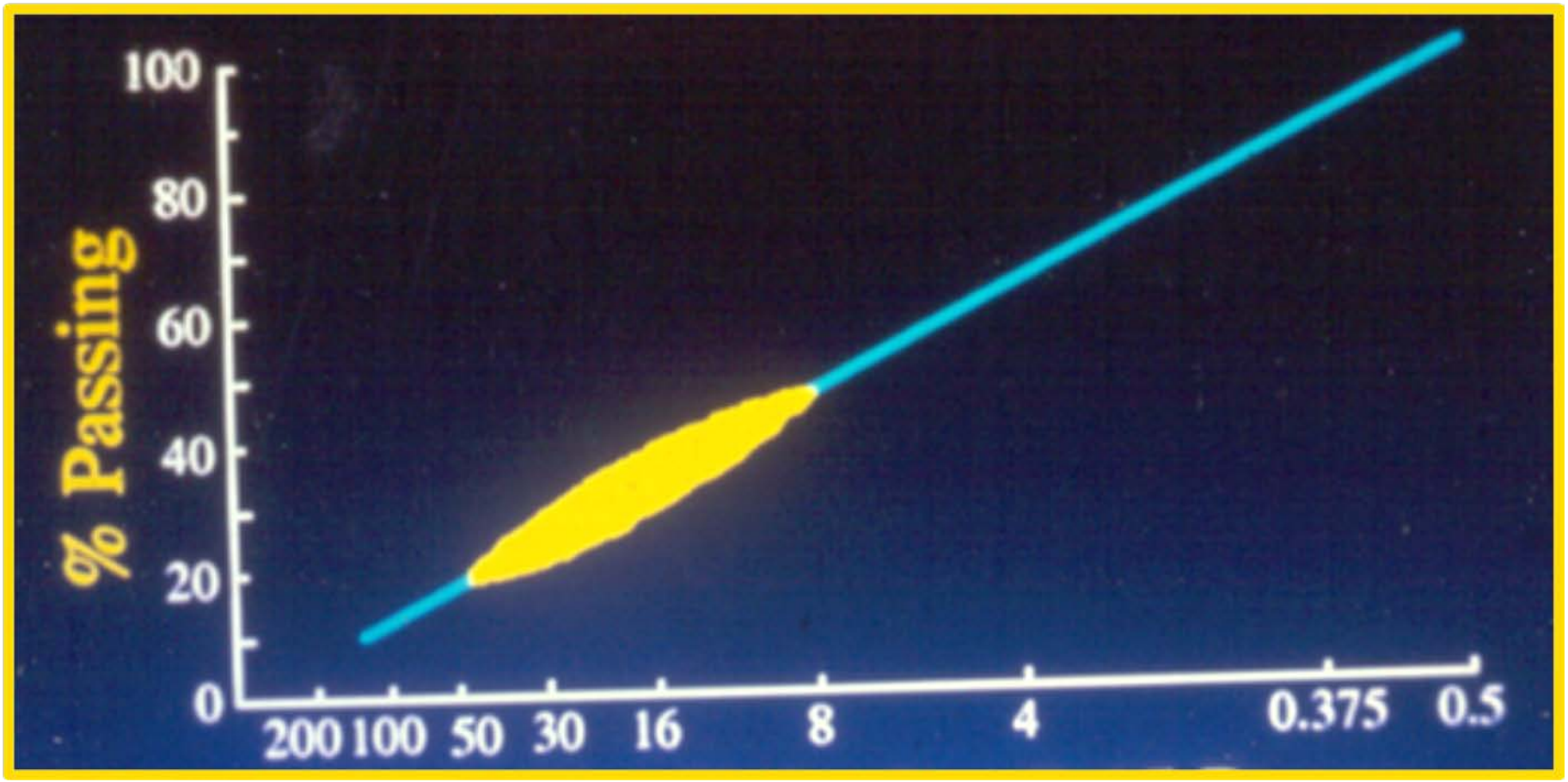
Mix Designs – Superpave (1990s)

- Gyratory compactor - orients the aggregate particles in a way similar to that observed in the field
- Number of gyrations are varied to simulate anticipated traffic
- Mixtures designed at 4.0% air voids
- Seven manufacturers & 12 models approved

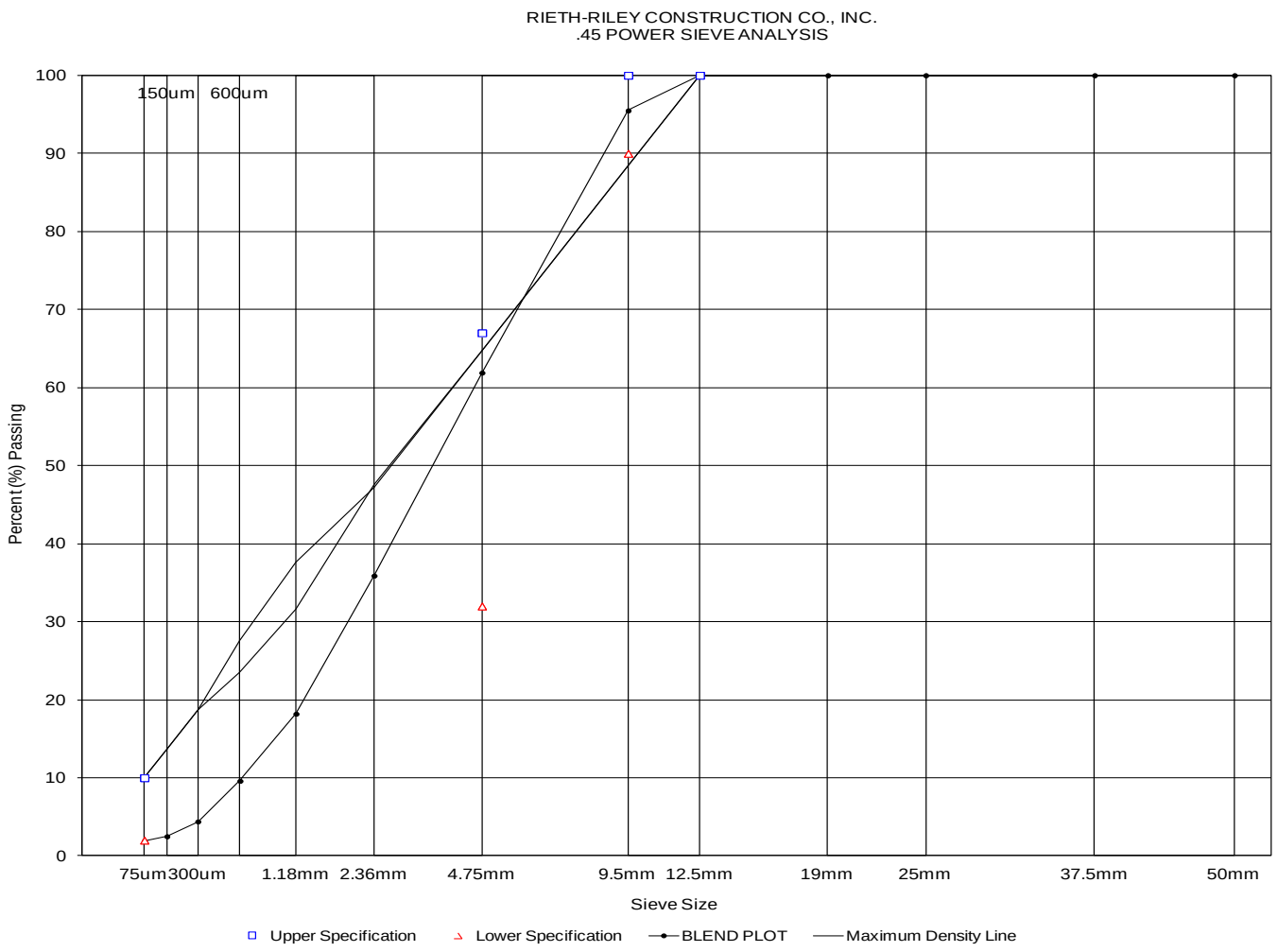
Mix Design - Superpave



Mix Design - Superpave



Mix Design - Superpave



HMA – Plant Sampling

Truck Sampling - Dense Graded, Open Graded & Sand Mix

Core Sampling - Density

Plate Sampling

- Final Place of Material
- Requires good coordination of plant, trucks and paving crew to obtain uniform mixture

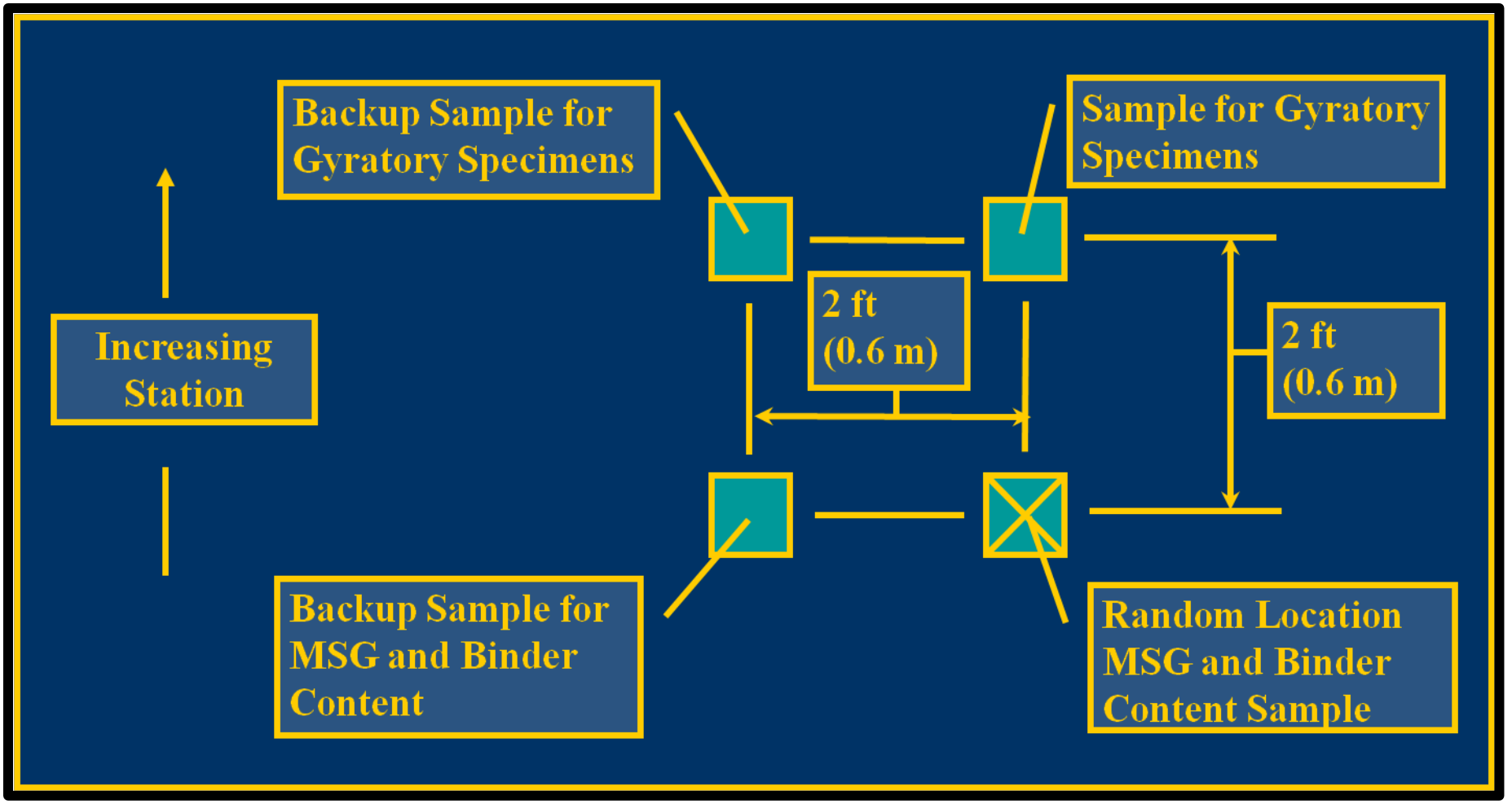
Plate Sampling

Plate Sampling

Plate Sampling

Plate Sampling

Plate Sampling



HMA – Testing

- Gradation
- Asphalt Content
- Air Voids
- VMA
- Density
- Smoothness

Testing - Gradation

HMA – Asphalt Content

- Centrifuge Extractor
  - Asphalt content with fines recovery
  - Recovery of asphalt for further testing

HMA – Asphalt Content

- Vacuum Extractor
  - Asphalt content with fines recovery
  - Biodegradable solvents – film on aggregate

HMA – Asphalt Content

- Ignition Oven
  - Total asphalt content
  - High Mg aggregates

HMA – Air Voids

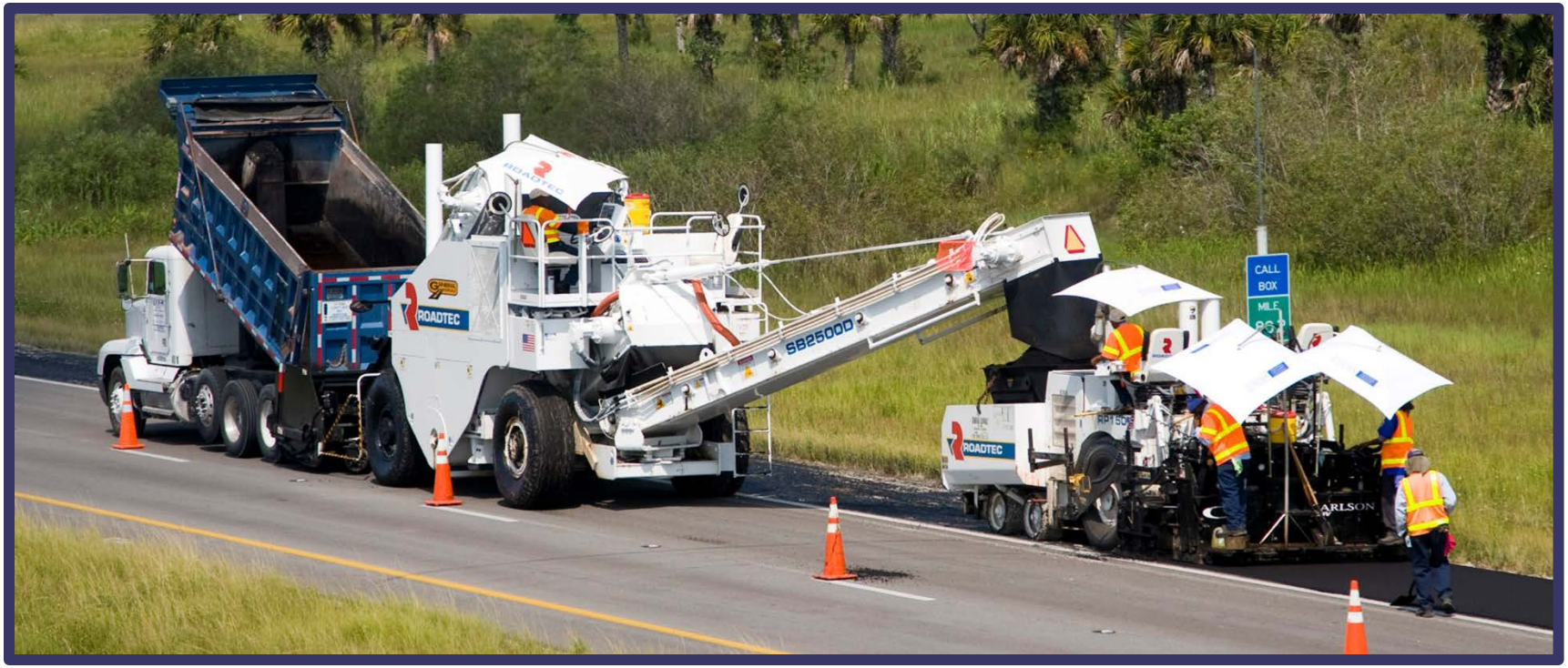
HMA – Air Voids

- Bulk Specific Gravity
- Maximum Specific Gravity – weighing in water

HMA – Density

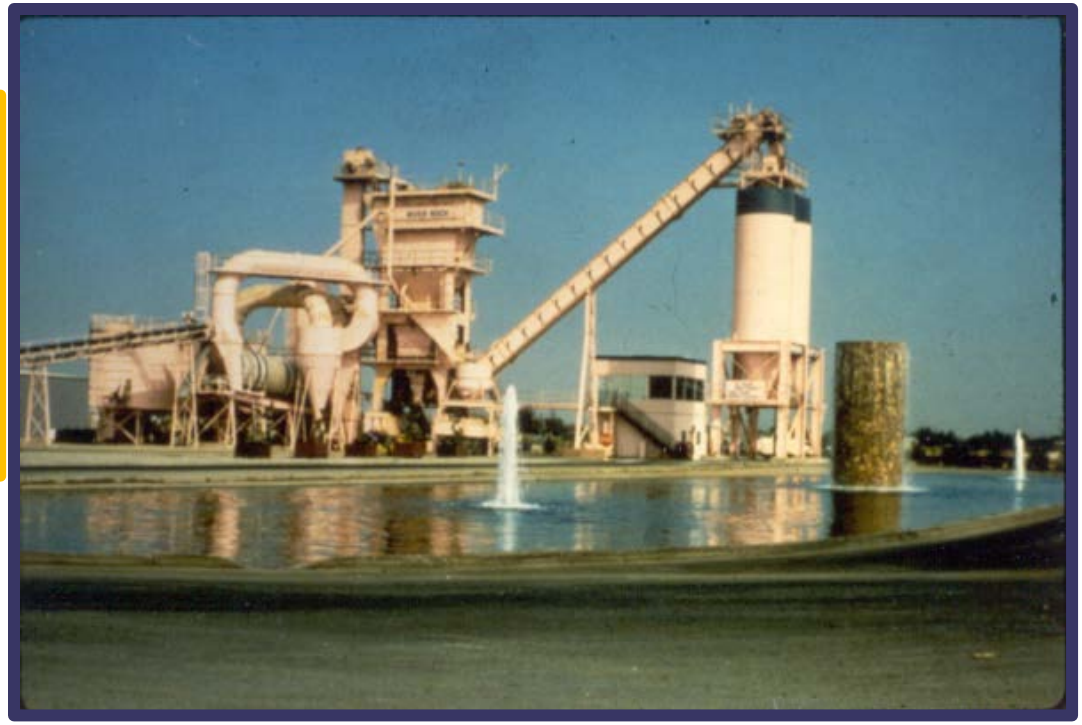
- Nuclear Gauge - nondestructive
- Cores

HMA – Equipment



HMA- Plants

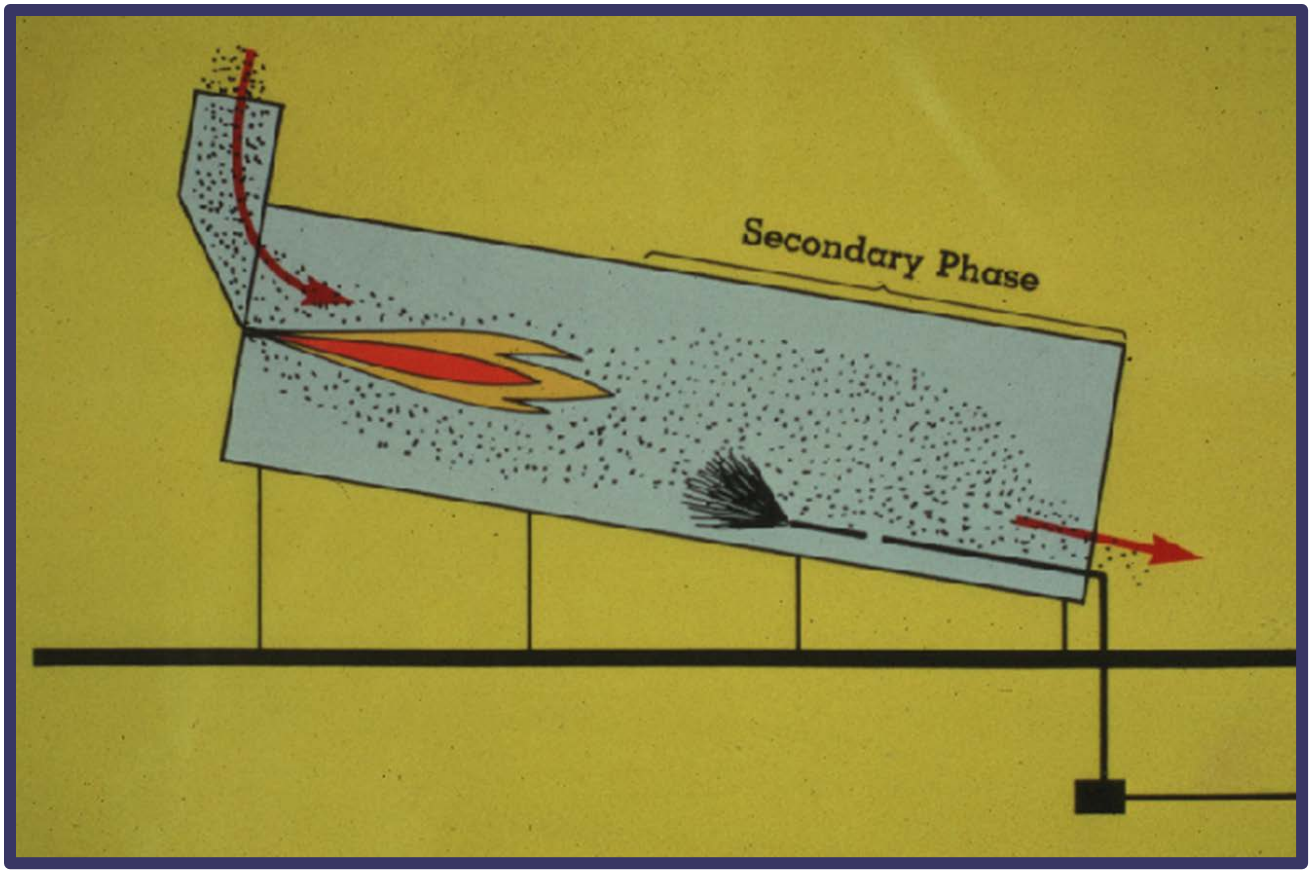
- Continuous
- Batch
- Parallel - flow
- Counter - flow



Continuous – Mix Plants

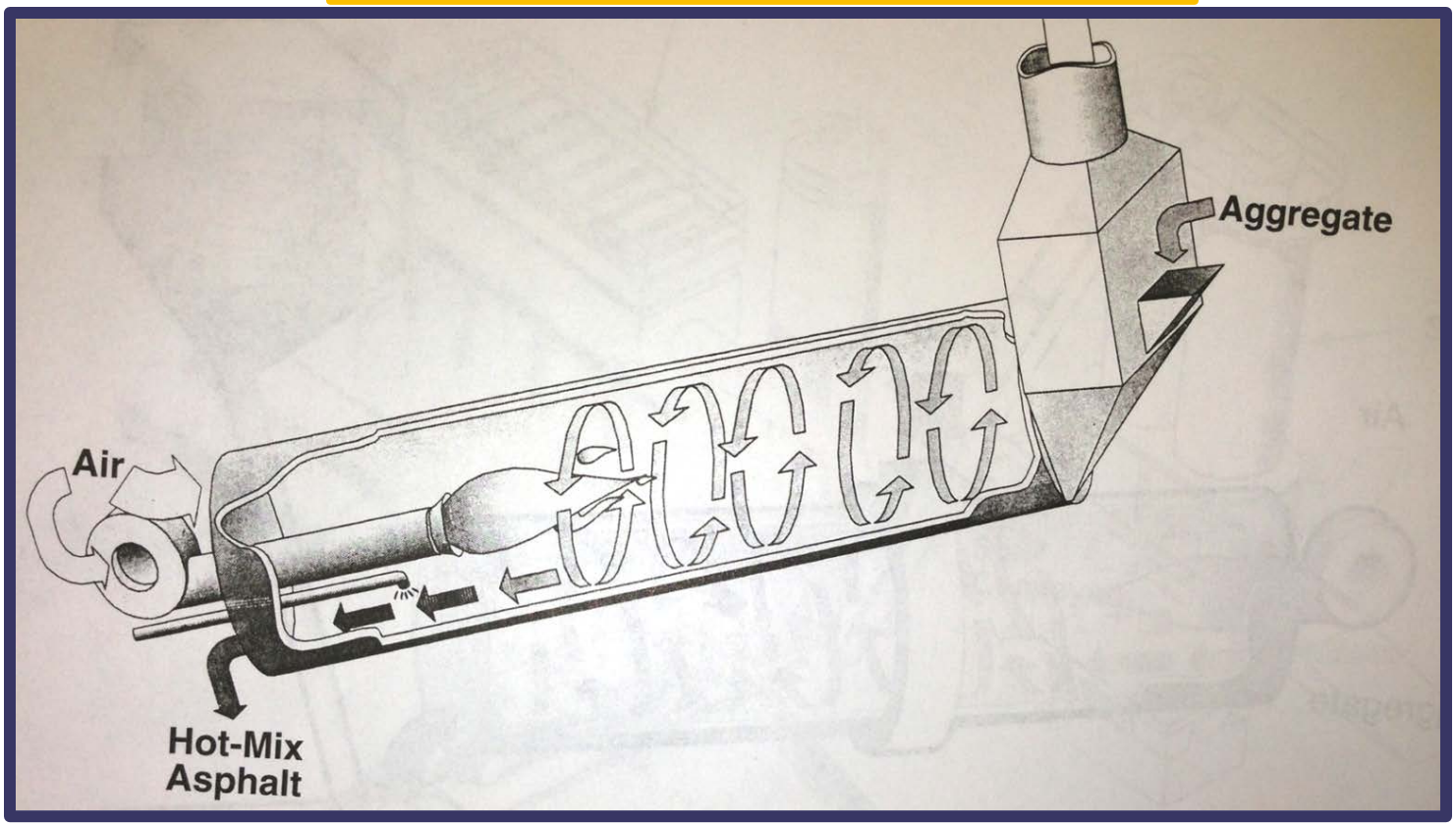
Batch Plants

Parallel-Flow Drum Plant



Mixture exposed to dryer burner - emissions

Counter -Flow Plants



Improve the heat transfer process inside the drum and reduce plant emissions

Double Barrel Plants

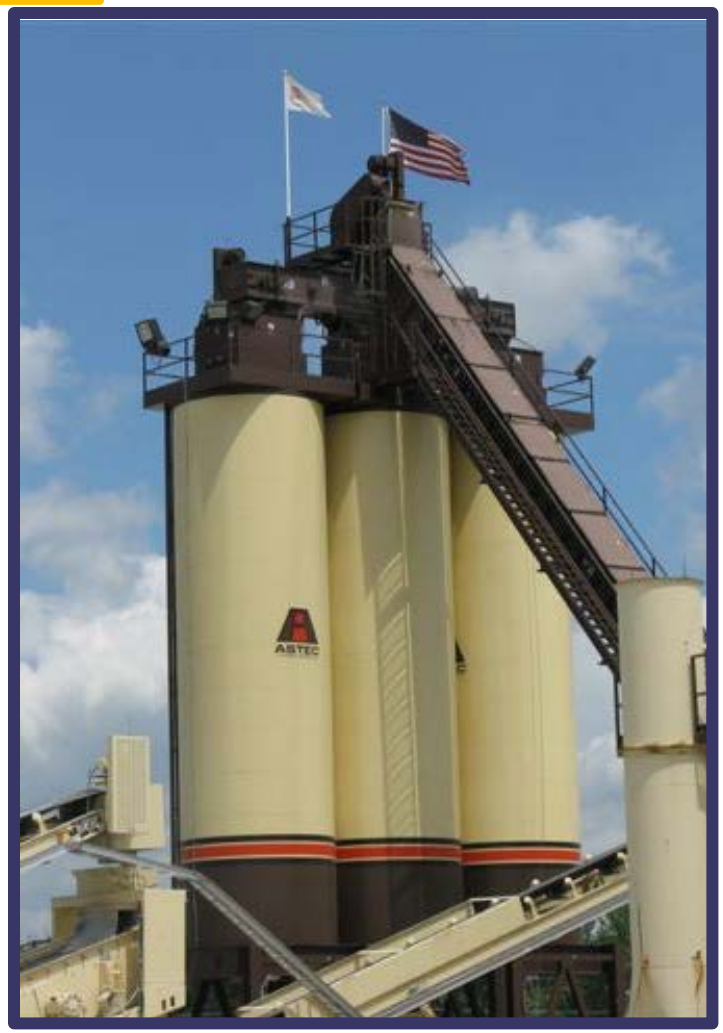
Protects the RAP from high-temperature exhaust gases and reduces visible emissions

Warm Mix Asphalt – 54 plants

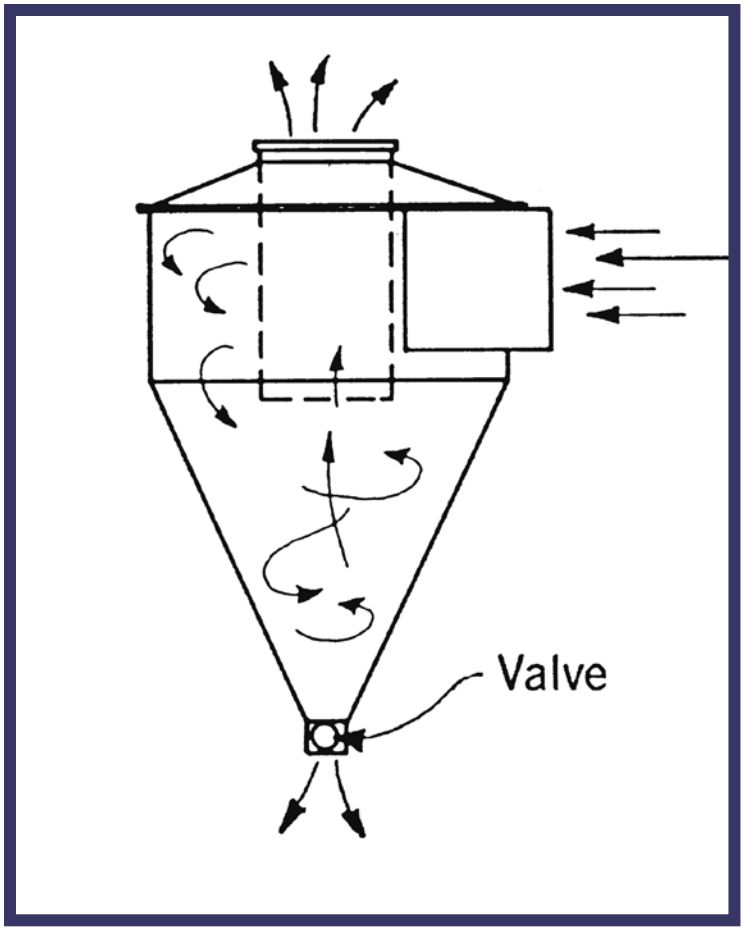
- Water Injection -- < 0.1% moisture in mix
- 250 – 260° F – reduces emissions
- Approximately 14% reduction in fuel
- Improves coating
- Mixture cools slower – longer haul distances

Surge Bins

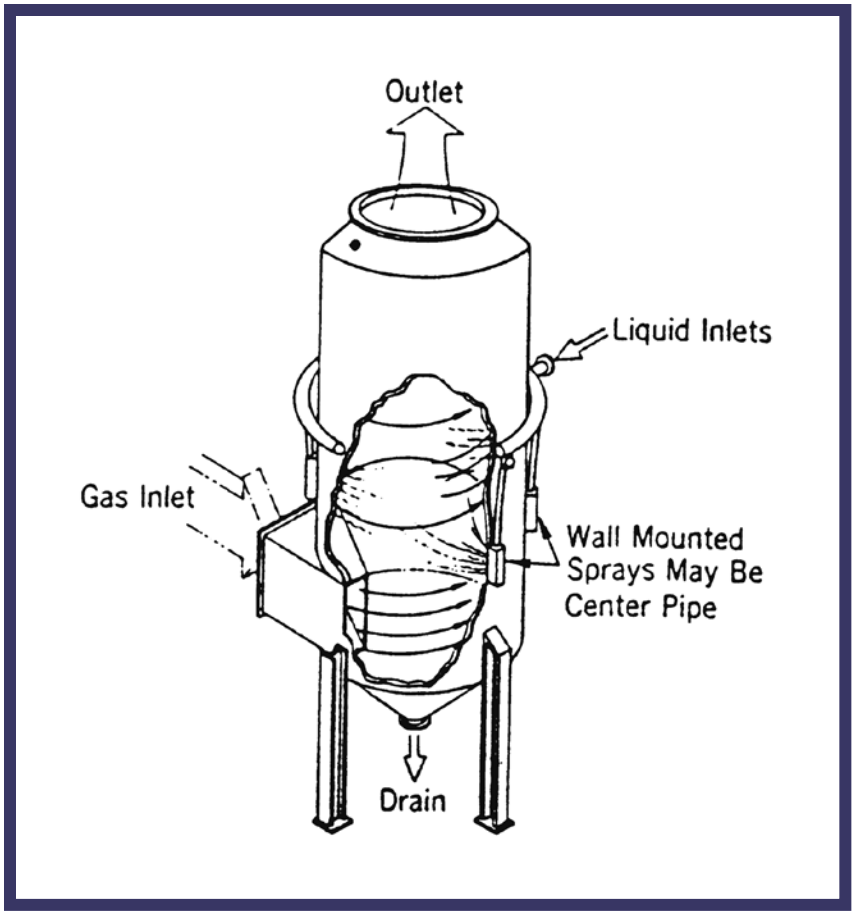
- Allows continuous flow of mix to contract
- Length of storage – hardening of asphalt and draindown



Dust Collectors



Cyclone



Wet Scrubber

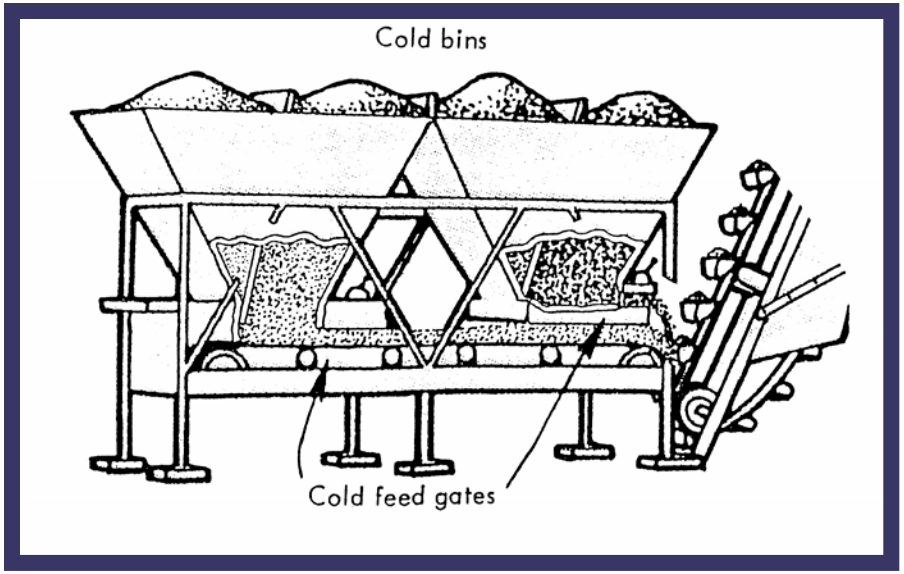
Baghouse

Allowed return of fines to mixture

Baghouse Fines

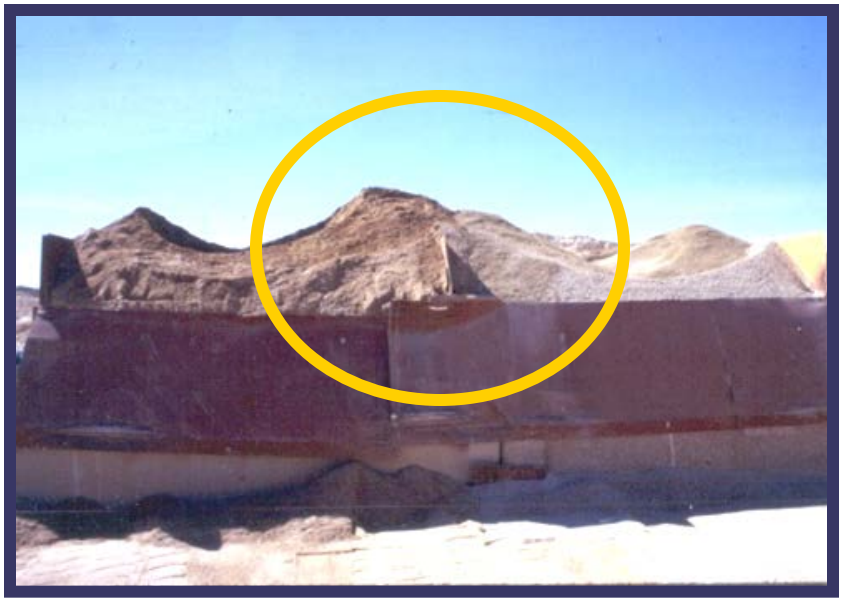
- Uniform return of the fines
- Calibration of fines vs rate of return

Cold Feed Bins



Cold Feed Bins

Cold Feed Bins



Asphalt Storage

Mass Flow Meters

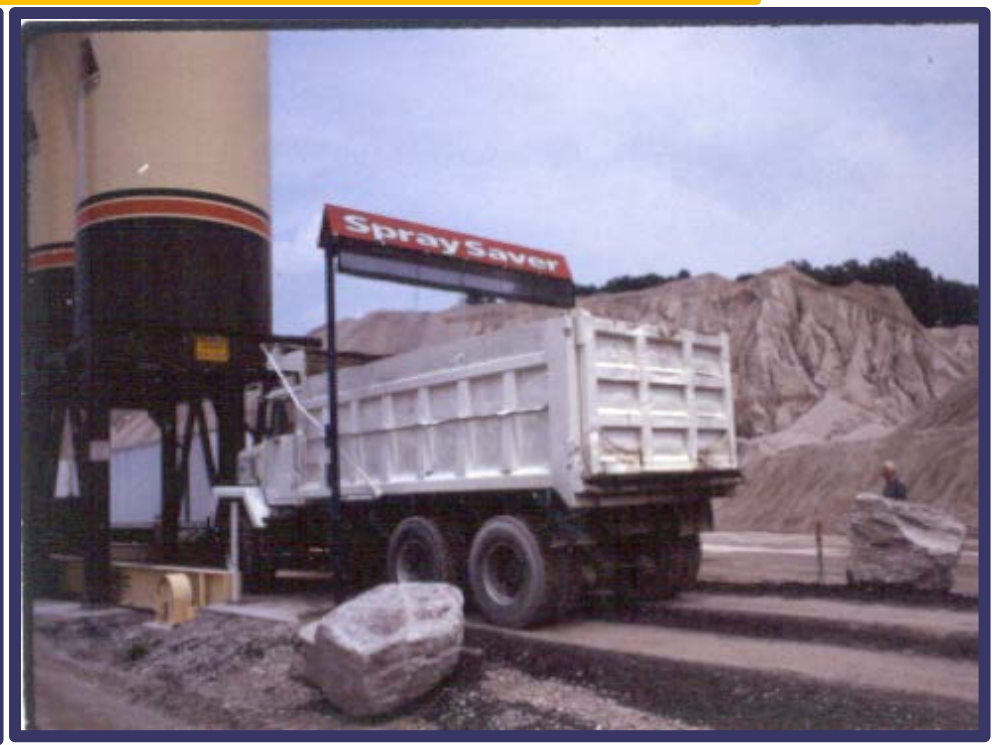
Trucks

Trucks – Anti Adhesive Agents

- Approved List
- Truck Beds raised after application of non-foaming agents

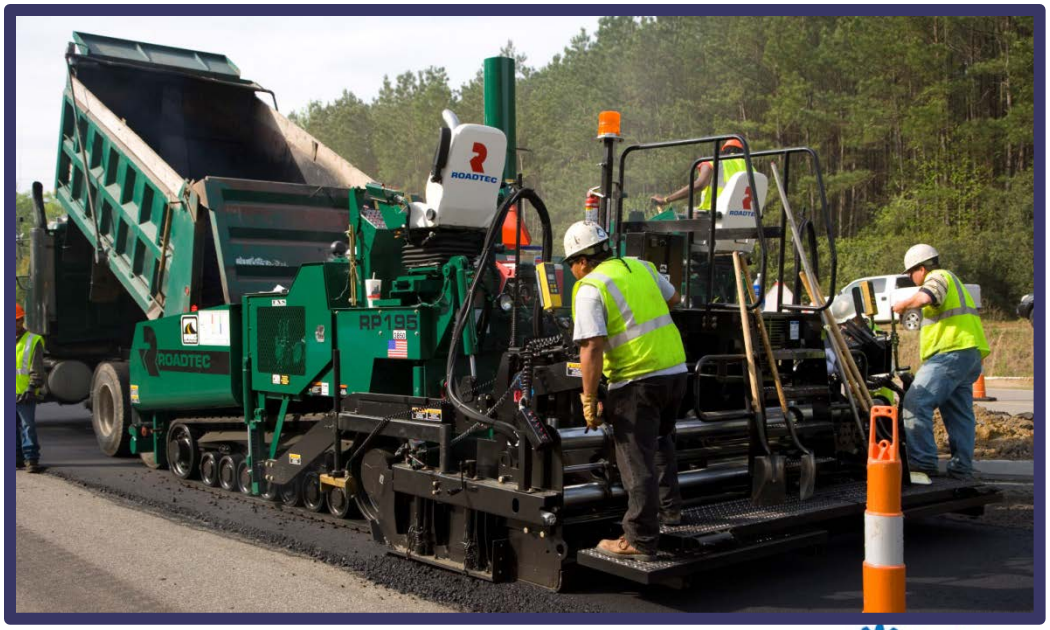
Trucks – Anti Adhesive Agents

Trucks – Anti Adhesive Agents

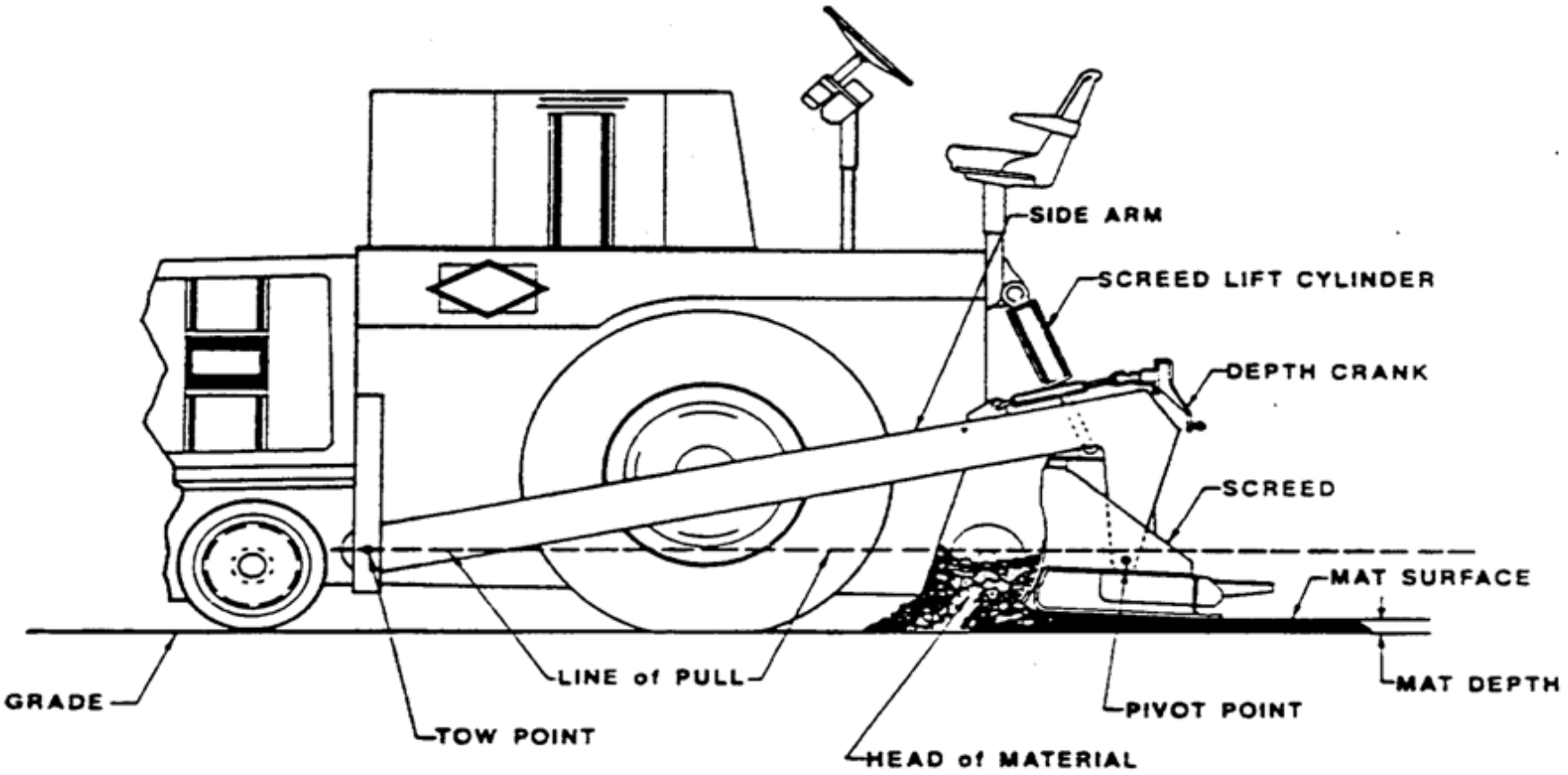


- Faster operation - Driver remains in truck
- Amount of anti-adhesive agent is controlled

Pavers



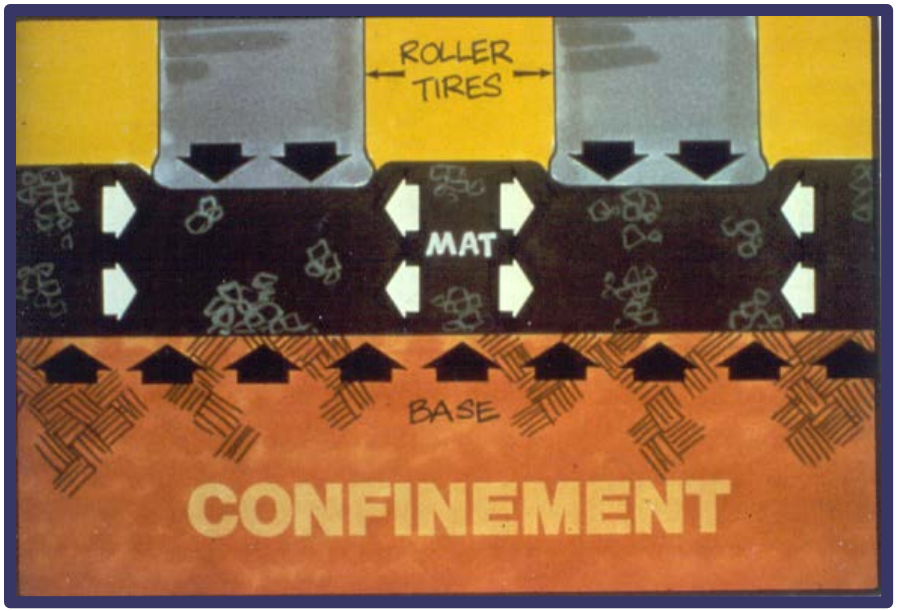
Pavers


SIDE ARM
SCREED LIFT CYLINDER
DEPTH CRANK
SCREED
MAT SURFACE
MAT DEPTH
GRADE
LINE of PULL
TOW POINT
PIVOT POINT
HEAD of MATERIAL

Rollers – Three Wheel

- 300 lb/in on rear wheels
- Tandem meeting this requirement could be used

Pneumatic Tire Rollers



- Contact Pressure of 50 to 90 psi
- Tire temperature – picking up

Rollers

Tandem Rollers

- Minimum of 10 ton weight

Rollers

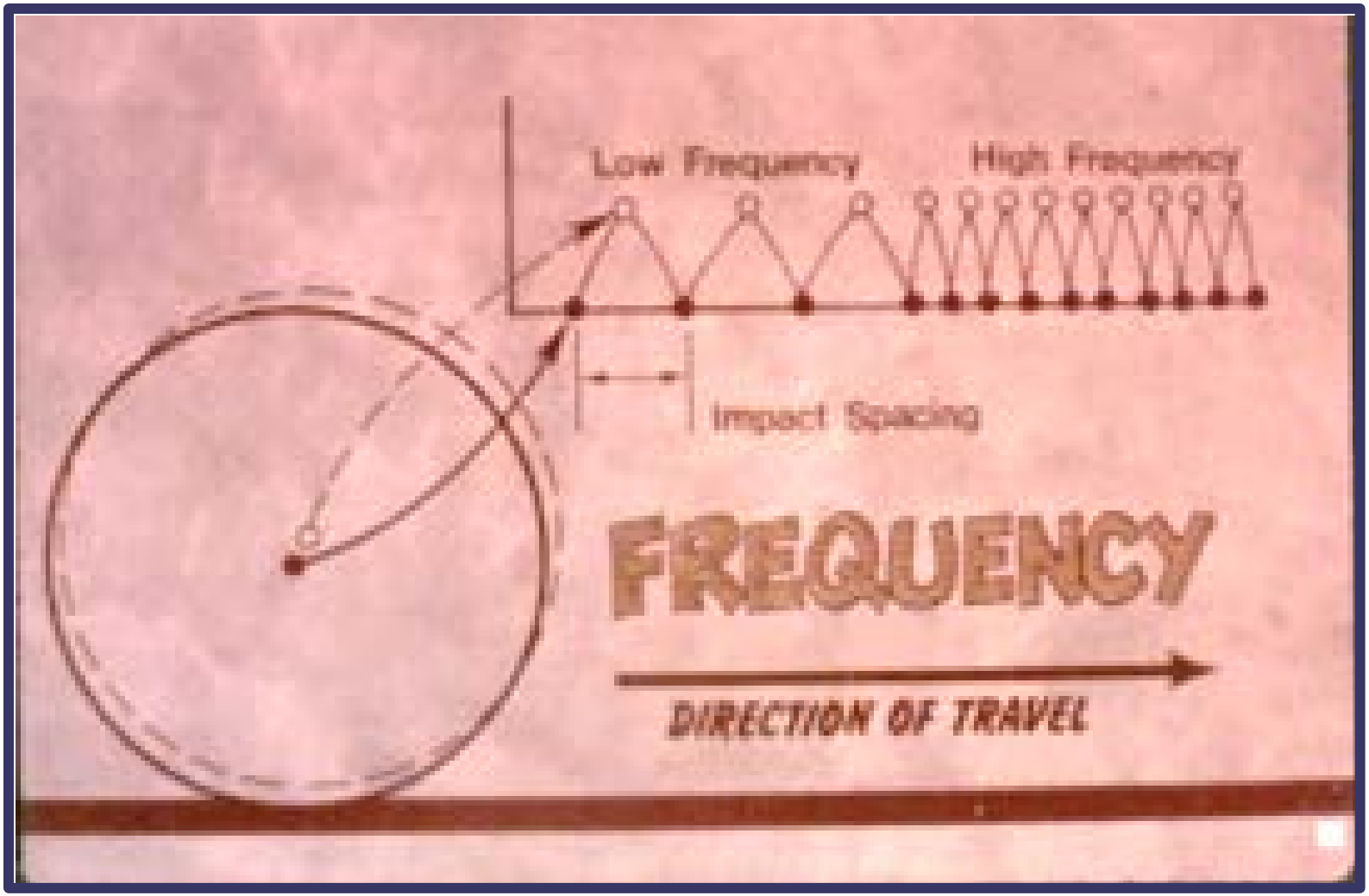
Single Drum Vibratory on Soil

Rollers

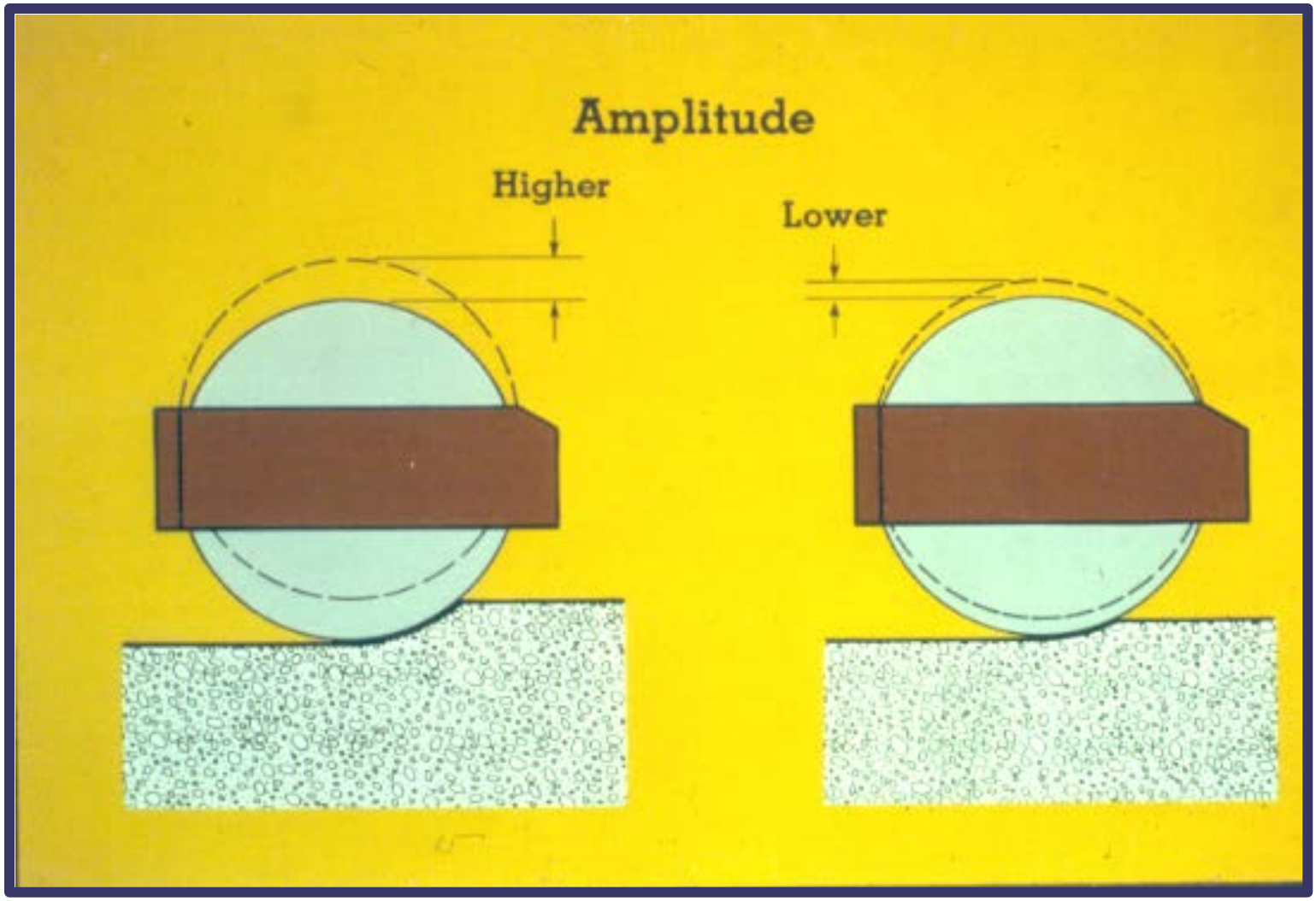
- Single Drum Vibratory on HMA
- ≈ 1500 vpm
- > 10 passes to achieve density

- Dual Drum Vibratory
- More compaction and wider drums
- ≥ 2000 vpm

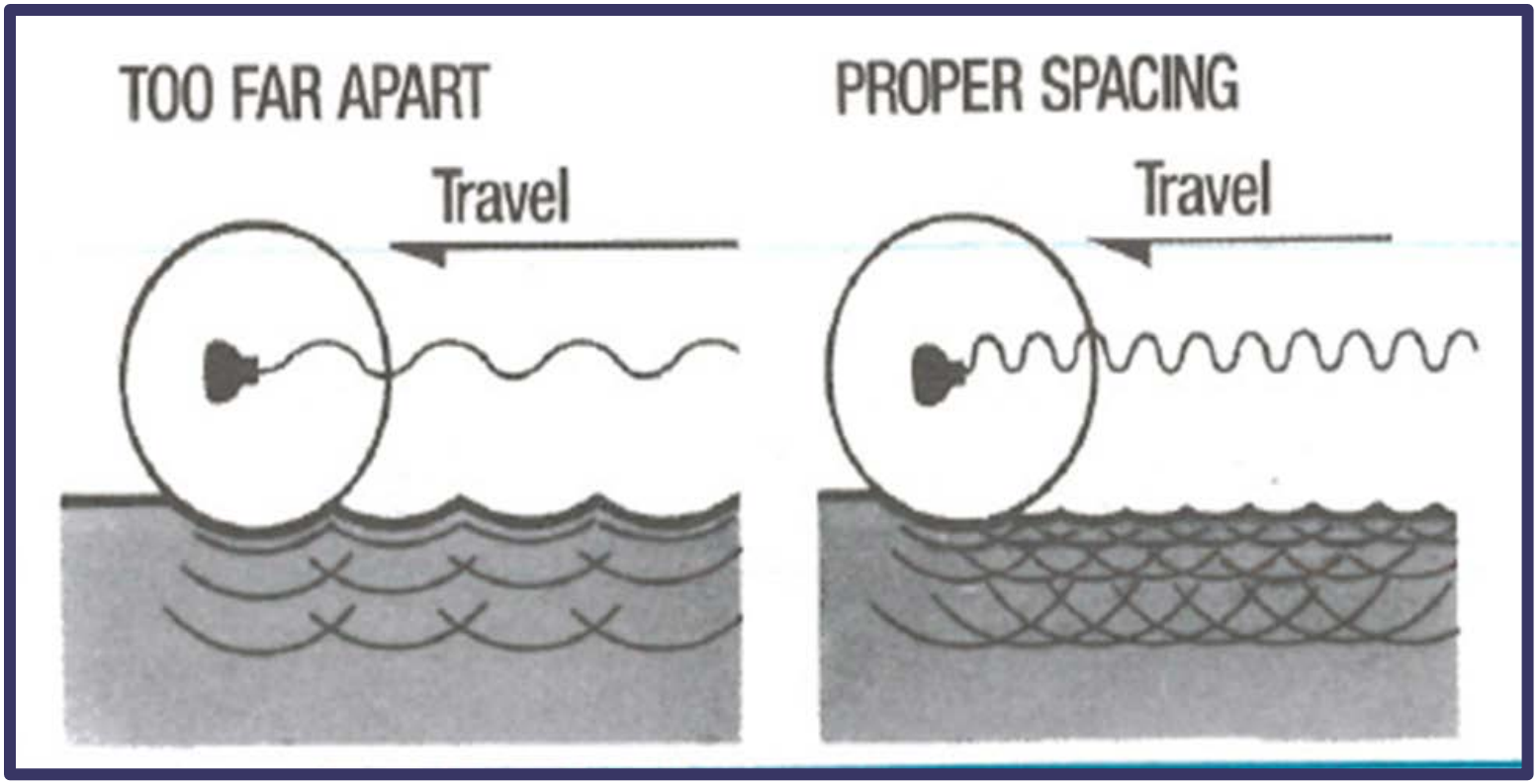
Vibratory Rollers - Frequency



Vibratory Rollers - Amplitude

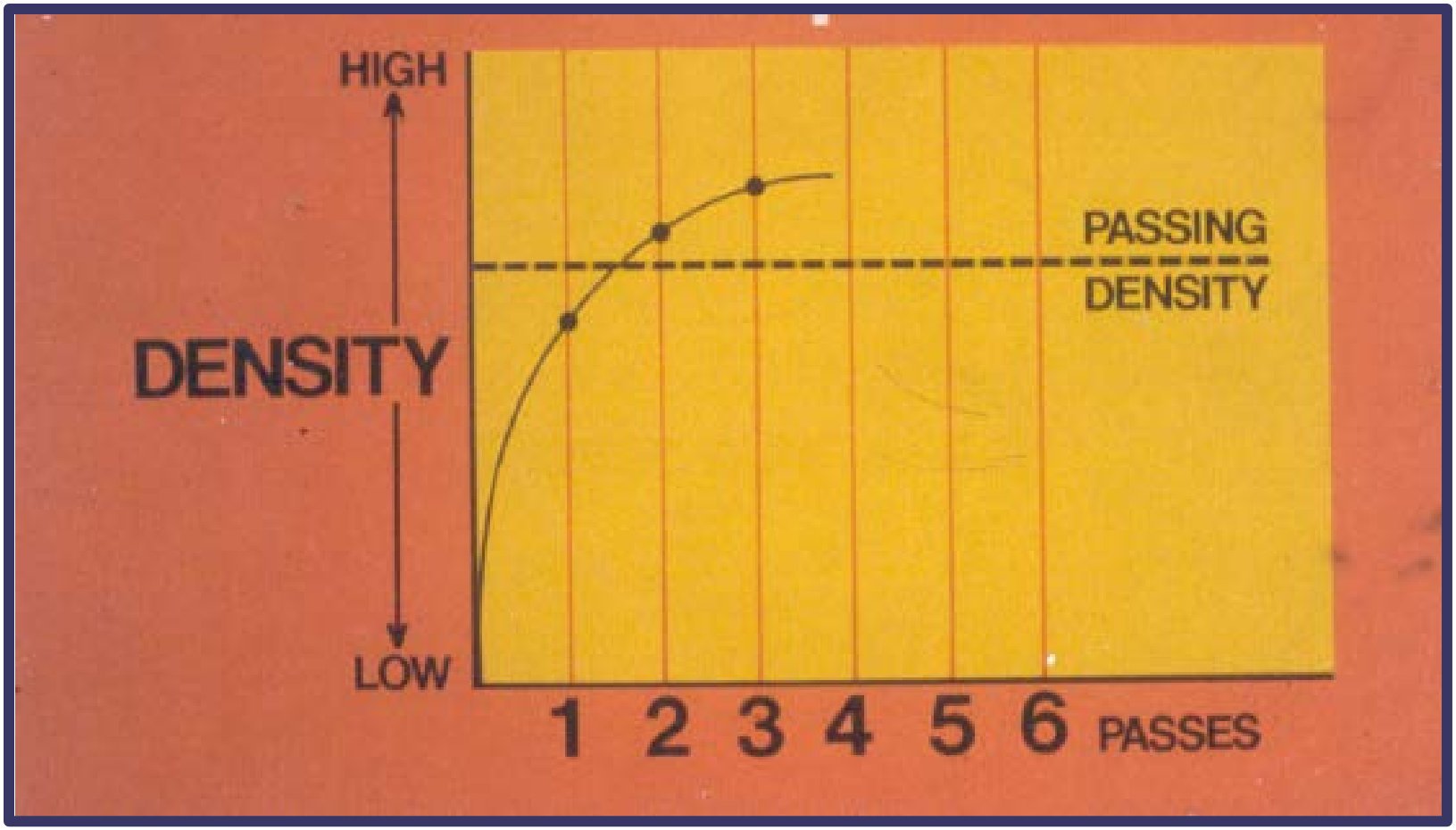


Vibratory Rollers – Speed



2000 vpm @ 2 ½ mph = 1 in. spacing of drum impact

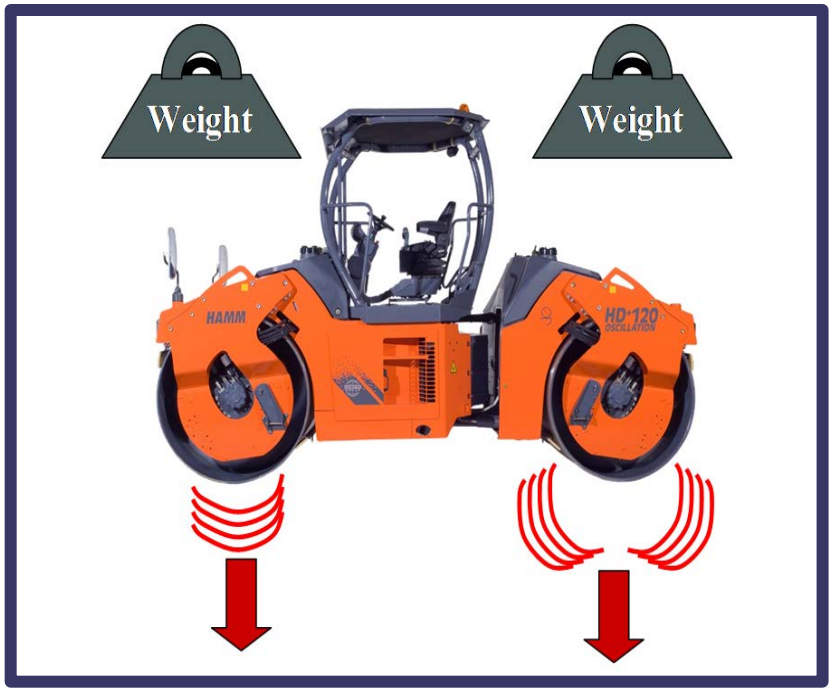
Vibratory Rollers – Test Strip



Approved Equipment List – Vibratory Rollers

Man.	Model	Base Material	Amplitude	Number 0f Passes (100-170)			
				vib	3 wh-vib	Pneum-vib	Vib-tand
Bomag	BW-202	asphalt	low	3	2-2	2-2	2-2
Case	752	asphalt	low	4	3-2	3-2	3-2
Tampo	RS-166	concrete	med	2	2-2	2-2	2-2

Oscillatory Rollers



Reduce impact on pipes and adjacent buildings in metropolitan areas

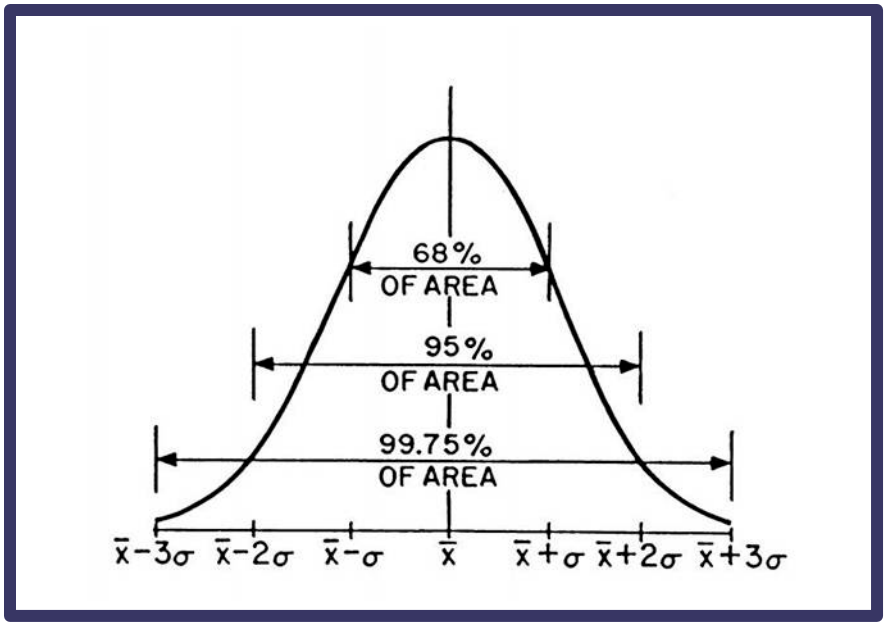
Density – Intelligent Compaction (IC)

- GPS radio and receiver unit on roller
- On-board documentation system
  - Stiffness values
  - Number of passes
  - Location of roller passes
  - Pavement surface temperature
  - Roller speed
  - Vibration frequencies
  - Amplitudes of roller drums

Problems - Rutting

- Number of Trucks
- Allowable load limits

QC/QA Specifications - 1984

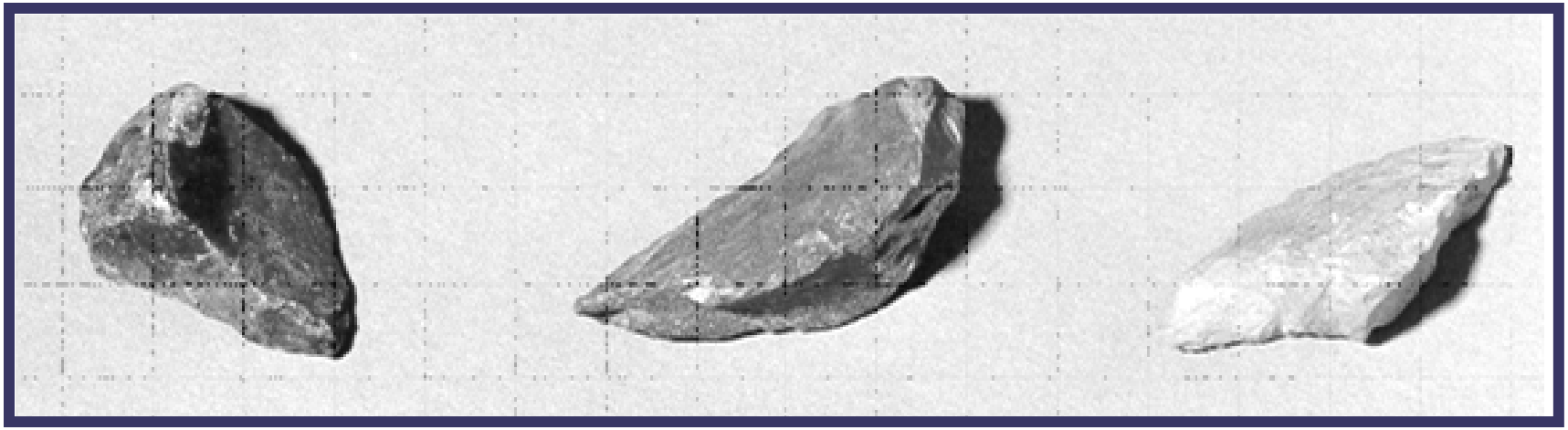


- **Quality Control (QC) – Contractor Process Control of producing quality mixture**
- **Quality Assurance (QA) – Acceptance by statistical means, with random sampling**

Mix Designs - Marshall

- Mixtures were designed at 6.0% air voids
- Larger percentage of coarse aggregate

Materials - Gravel



- Crushed Count – 1960s
- Base mixtures – 50 %
- Binder mixtures – 50 %
- Surface mixtures – 85 %

Materials - Gravel

COARSE AGGREGATE ANGULARITY		
TRAFFIC, ESAL	DEPTH FROM SURFACE	
	≤ 4 in.	> 4 in.
< 300,000	55	
300,000 to < 3,000,000	75	50
3,000,000 to < 10,000,000	85/80*	60
10,000,000 to < 30,000,000	95/90*	80/75*
≥ 30,000,000	100/100*	100/100*

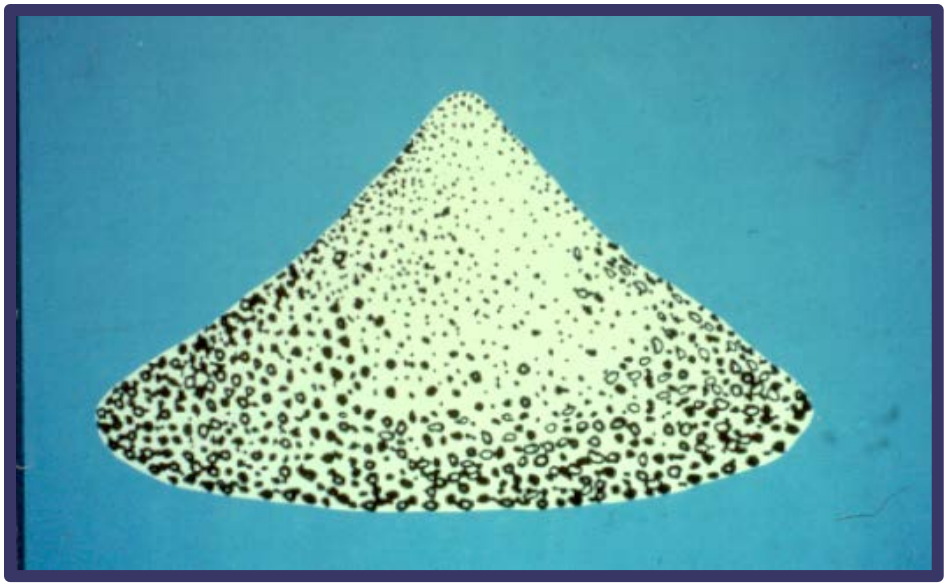
* Denotes two faced crush requirements.

Baghouse Fines

- Bins - low level indicator
- No return of Fines
- Adjust volumetric properties

Problems - Segregation

Materials – Aggregates (CAPP)



Reduce segregation of aggregates with stockpiling procedures

CAPP – Loading Trucks

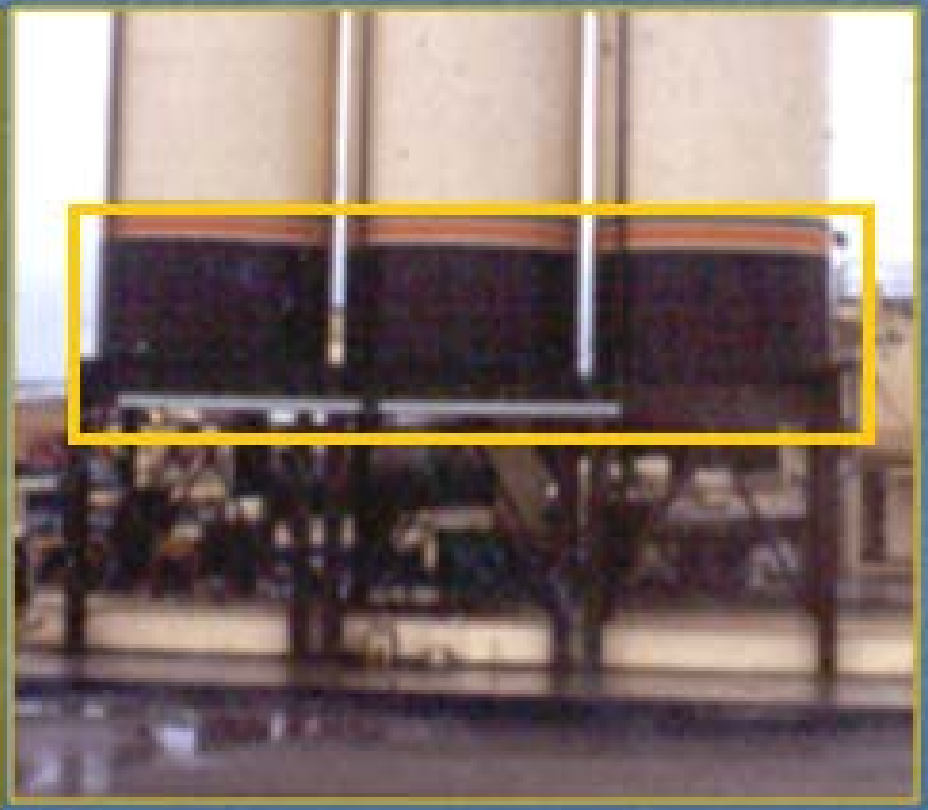
Three drops in truck and working across face of stockpile

HMA Plant - Cold Feed Bins

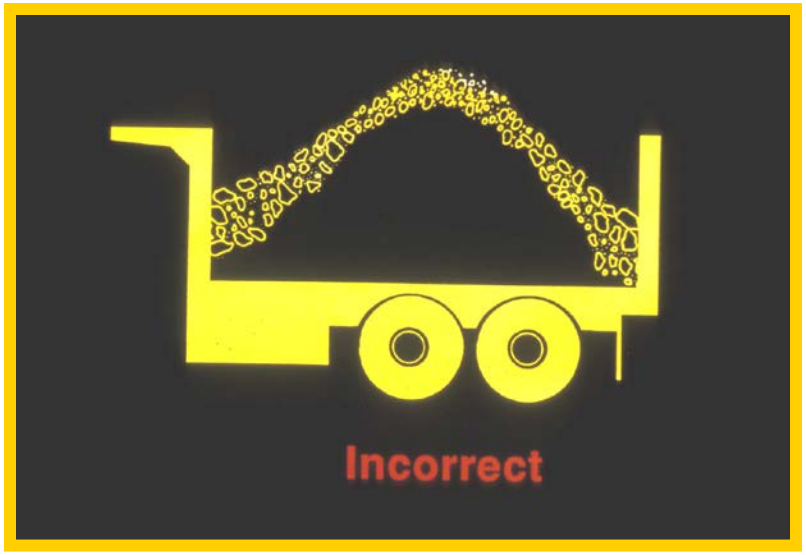
HMA Plant - RAP Bins

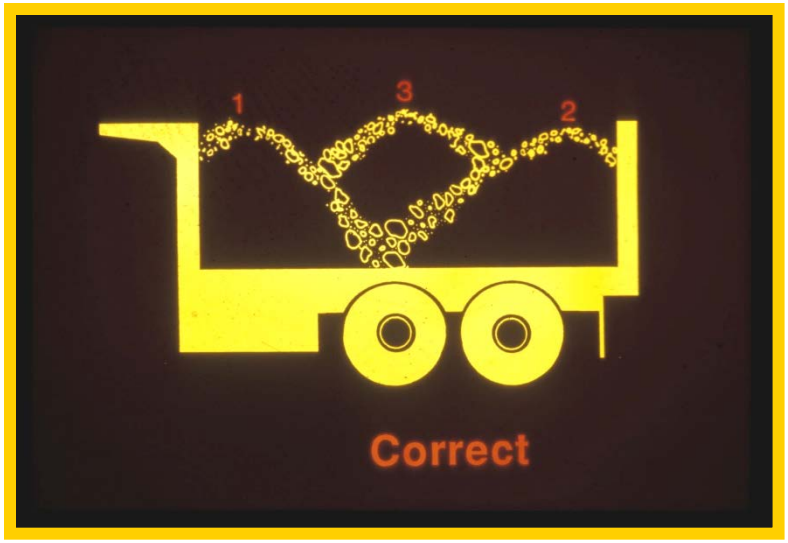
Surge Bins

- Discharge when mix falls below top of cone
  - Mix segregation
  - Alarm system



Trucks - Loading





Trucks – 3 Drops

Front

Back

Middle

Loading Trucks

Rear Axle Overload

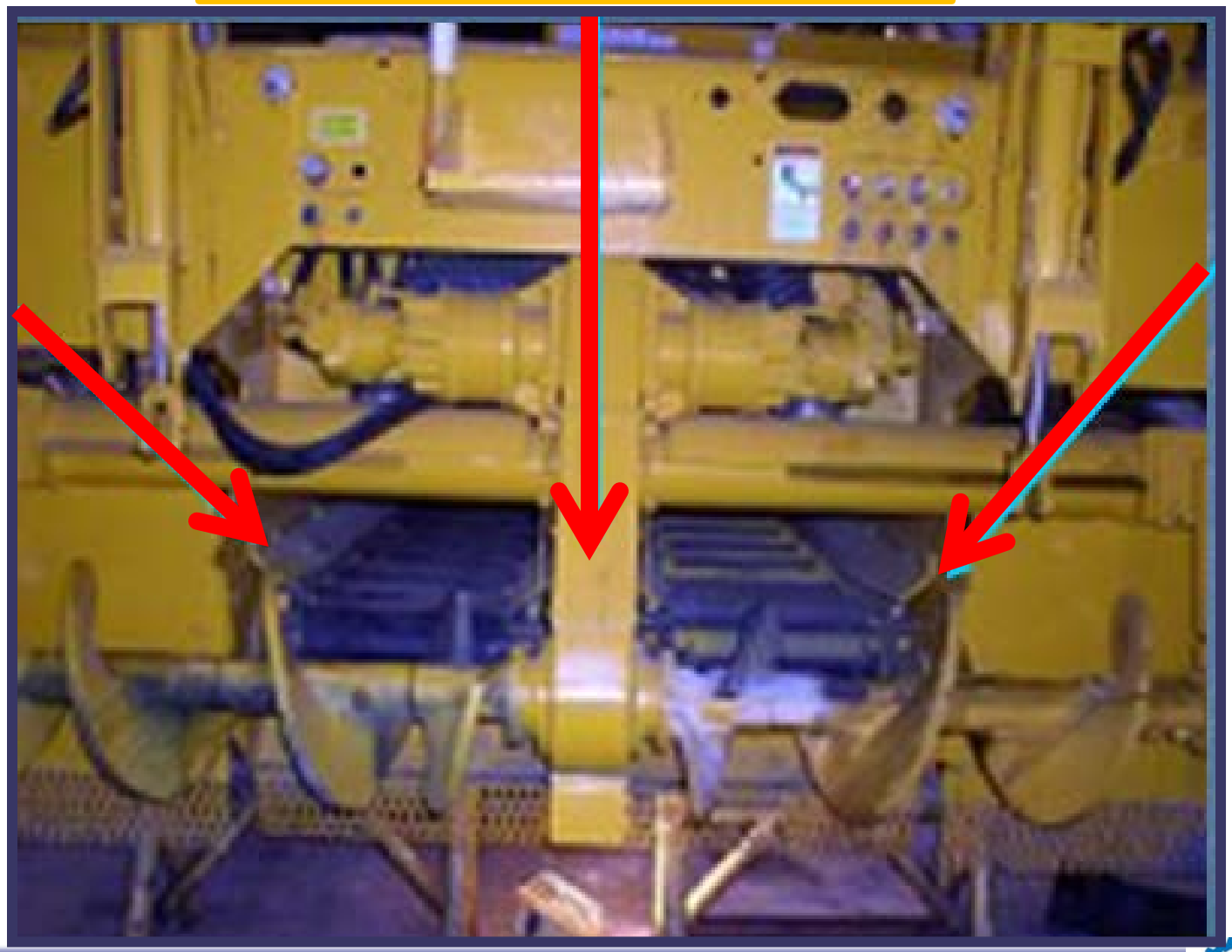
Material Transfer Vehicles

Transfer mix to paver – where trucks could not unload easily

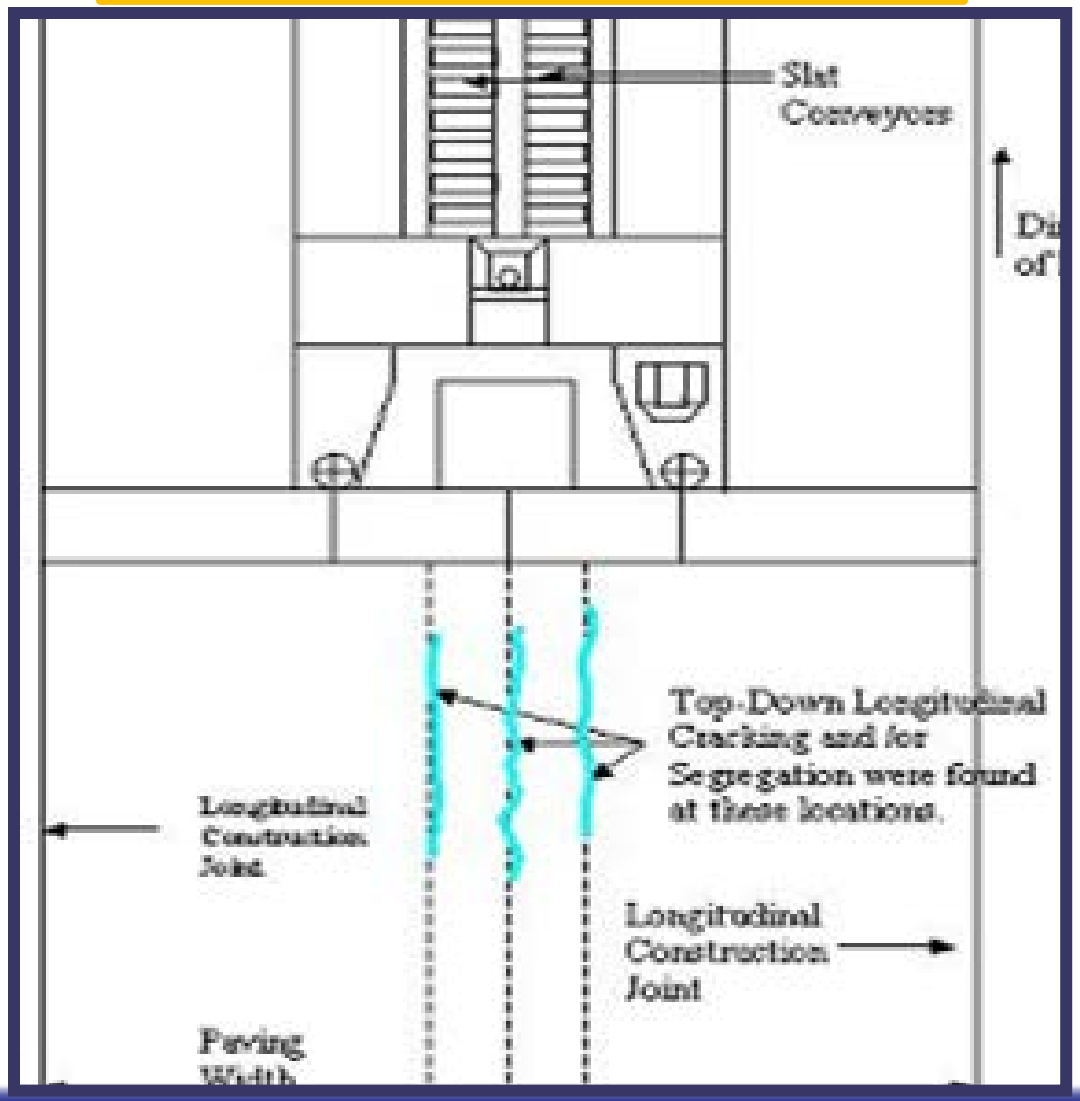
Material Transfer Vehicles

- Reduced Segregation
- Trucks could unload quickly
- Provided uniform mat temperature

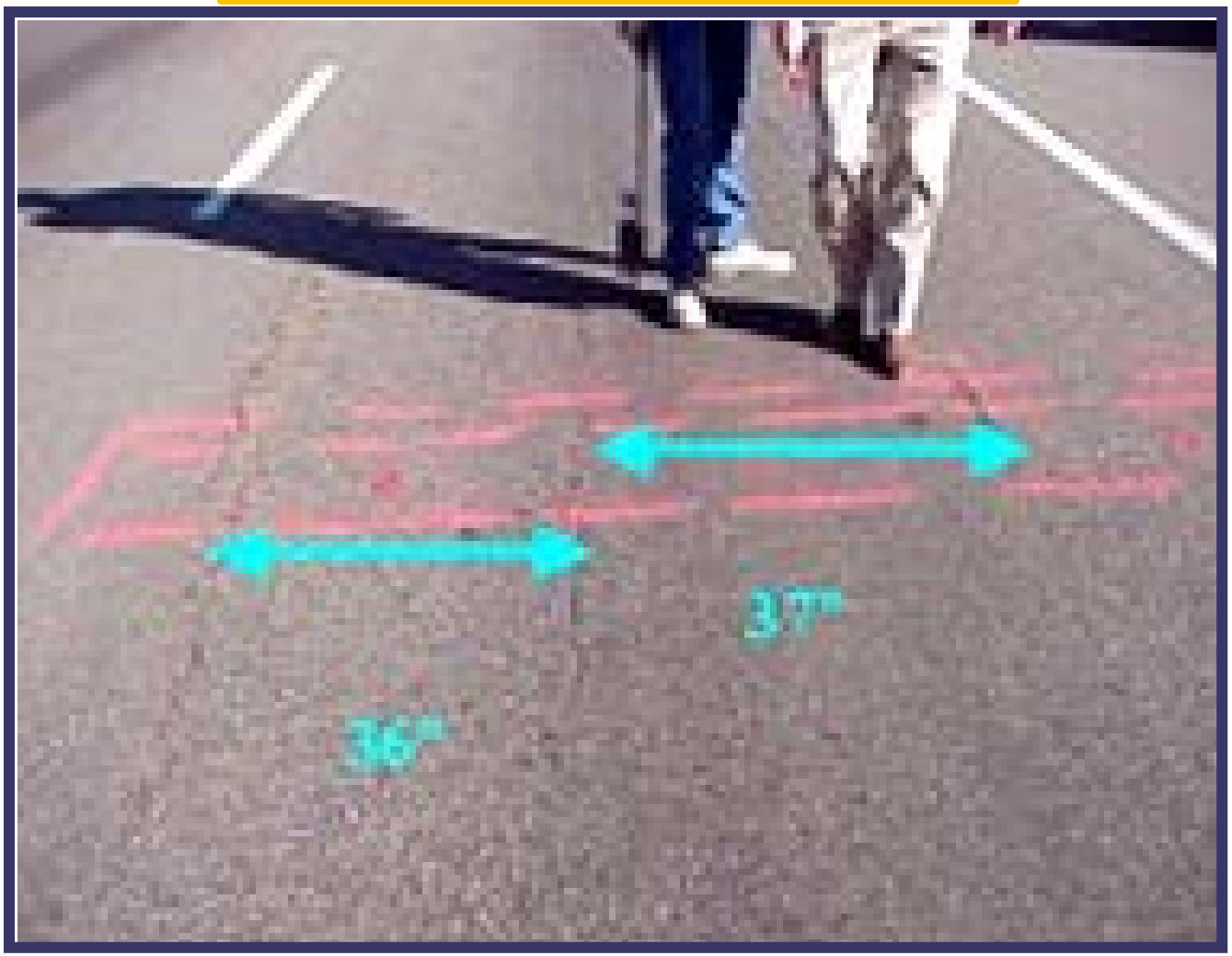
Paver - Segregation



Paver - Segregation



Paver - Segregation

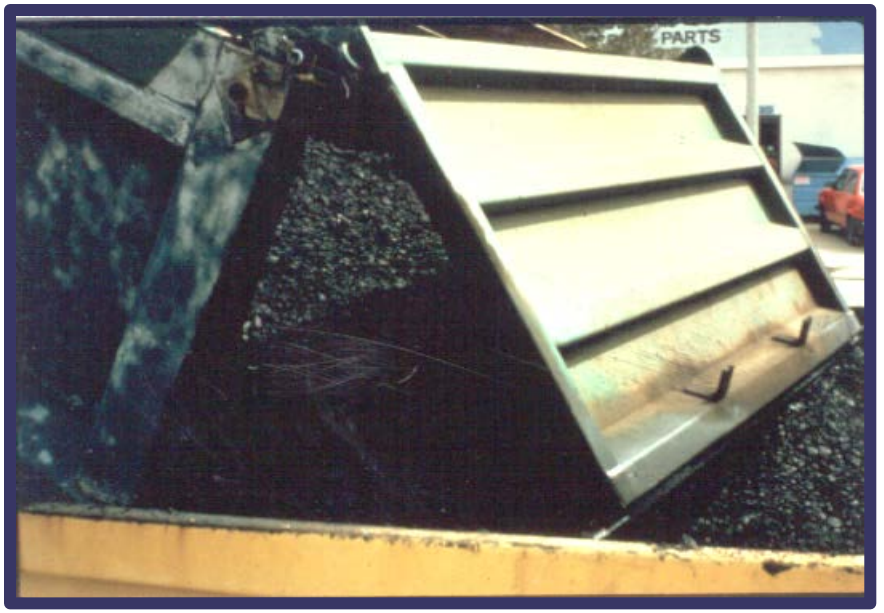


Paver Restrictions

- Blaw-Knox – MMK
- Cedarrapids – 1989 or later
- Barber Green/ Caterpillar – Deflector Kit

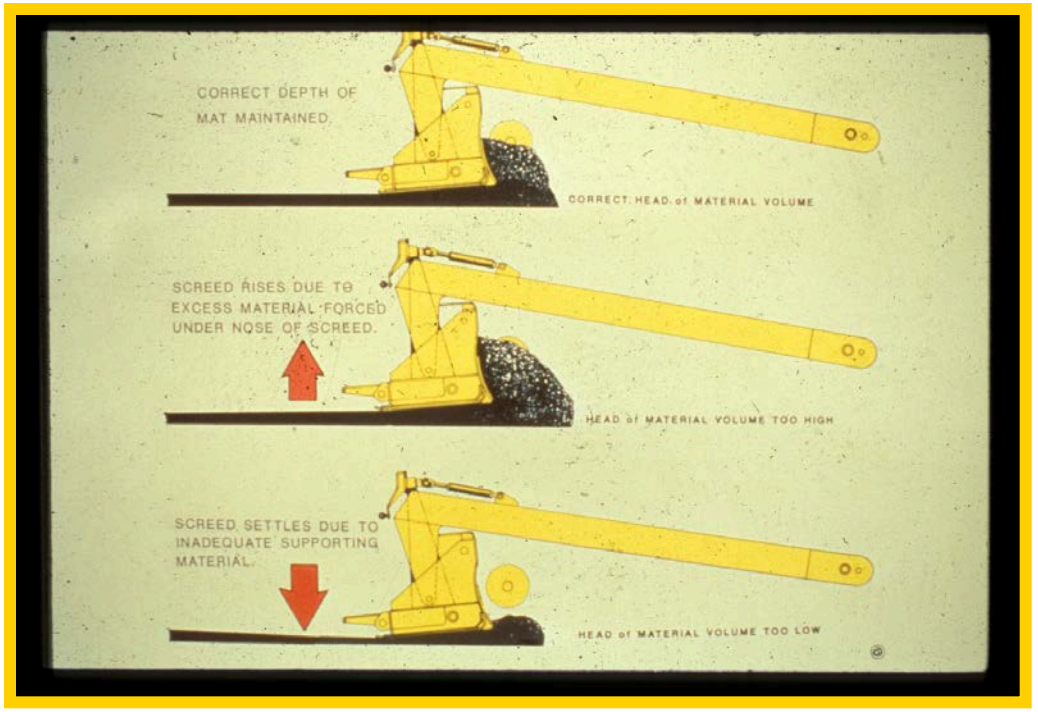
Pavers - Segregation

Pavers - Segregation



- Raise bed before unloading
- Flood the paver hopper

Pavers - Segregation



Constant Head of Material on Screed

Plate Sampling - Segregation

Quality Control - Plant

109 Certified HMA Producers

Quality Control - Plant

- Personnel
- Materials
- Laboratory
- Plant Production
- Sampling
- Testing
- Documentation

- Certified Asphalt Technician Training - 1984
- ≈ 800 Technicians
- Currently 227 Certified Technicians

QCP -HMA Laboratory

- Owned by Producer
- HMA Plant
- Other Locations
  - Results furnished in writing to plant within two working days
  - Equipment calibrated
  - Certified Asphalt Technician
  - Qualified Technician

QCP-HMA Plant Production

- Plant site layout
- Plant calibration
- Aggregates
- Binder
- Baghouse fines
- Fibers
- Trucks
- Surge bins

Testing – QCP Requirements

- Aggregates
  - Stockpile
  - Blended Aggregate
- Recycled Materials
  - Binder Content
  - Gradation
  - Moisture Content
  - CAA
- Binder

Testing

- Mixture at HMA Plant
  - Binder Content
  - Gradation (SMA)
  - Moisture Content
  - Temperature
  - Draindown (OG & SMA)

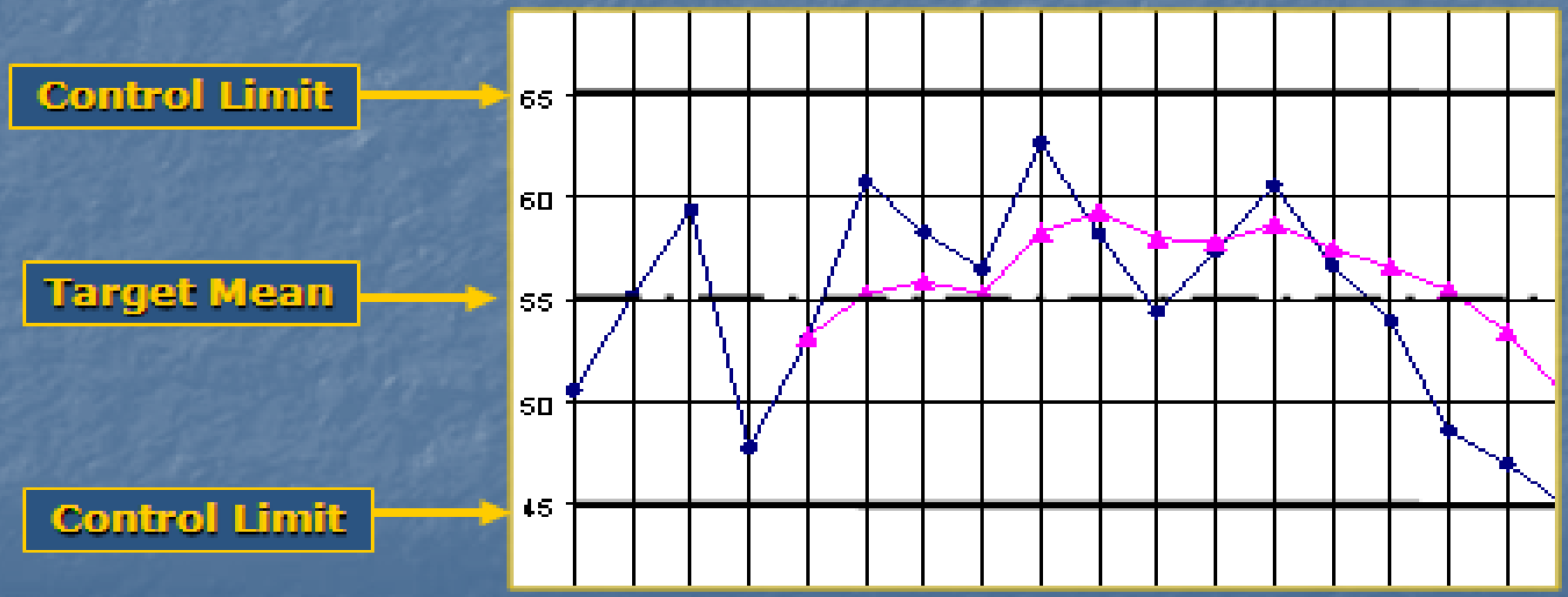
Testing

- Mixture from Pavement
  - Binder Content
  - Gradation (SMA)
  - Moisture Content (Surface Mixture)
  - Bulk Specific Gravity
  - Maximum Specific Gravity

Daily Diary

- Quantity of mixture produced
- Contract number
- When samples taken & tested
- Non-conforming tests and resulting corrective action
- Any significant events or problems

Control Charts



Certified HMA Plants

- Manufactured product
- Improved quality of product
  - React quickly to changes
- Cities/Counties use

Quality Control - Road

Personnel

- QCP Manager – responsible for administration of QCP
- QCP Field Manager – responsible for execution of QCP and liaison to PE.

  Required to be a Certified HMA Field Supervisor
- Quality Control Technician – responsible for conducting quality control tests and inspection

Quality Control Technician

- Paving operations and joint construction
- QC tests for temperature, density and smoothness
- Pavement samples

MILLING

- Milling Plan – general procedures for asphalt removal
- Equipment – description
- Testing – macrotexture measurement (ITM 812)
- Procedure, frequency, and equipment for measuring the cross slope and longitudinal surface finish

Process Balance

- Plant Production
- Transportation
- Placement
- Compaction
- Corrective Action

Transportation of Mixture

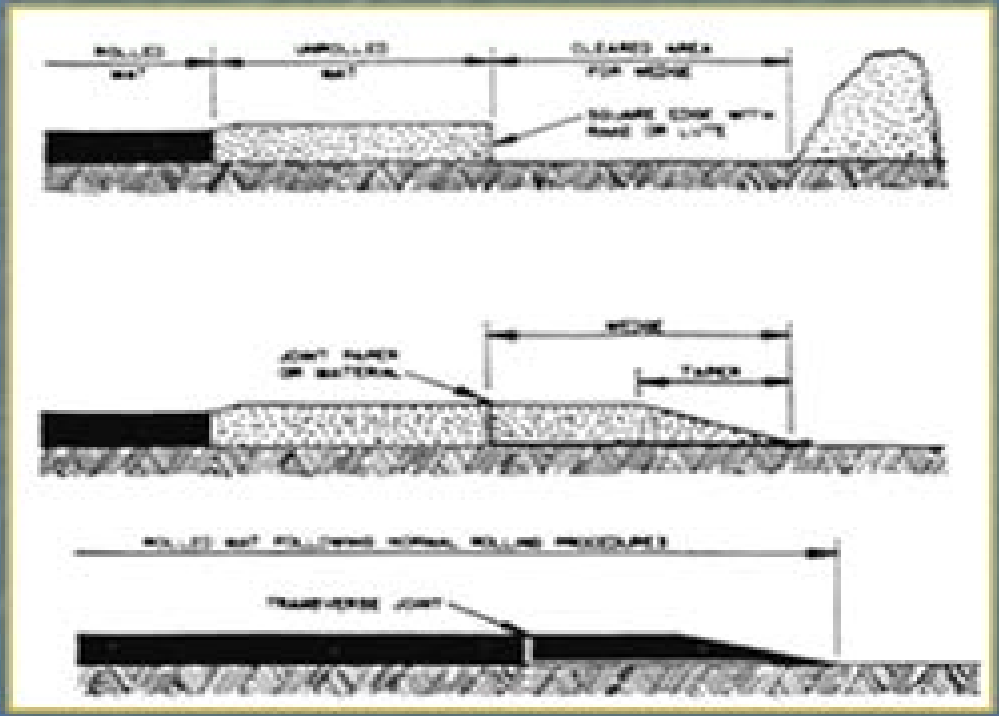
- Truck Bed Cover – when waterproof covers are used
- Unloading – procedures and removal of mixture from truck bed and bed apron
- Transfer Vehicles – type and size and plans for bridge crossing

Paving

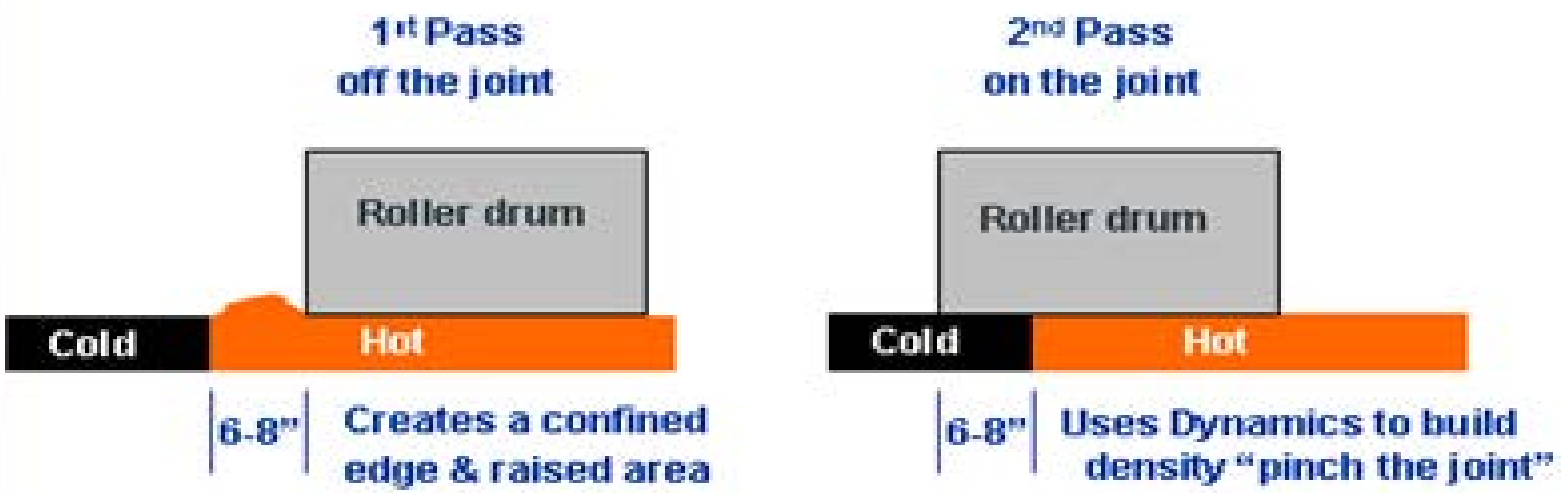
- Equipment – make, model, etc.
- Paving Plan – general sequence, widths, and depths of paving, and planned date for starting and finishing

Paving - Joints

- Procedure for construction of longitudinal and transverse joints
- Starting and stopping procedures of paver for transverse joints



Joint Compaction



- **Procedures for compaction of the longitudinal and transverse joints**

Materials Sampling and Testing

- Density – procedure for measuring (minimum 1/1000 yd^2 on mainline and shoulders)
- Procedure for monitoring temperature of mix during compaction to optimize rolling pattern

Materials Sampling and Testing

- Plan for when cores shall be taken and procedure for refilling core holes

Materials Sampling and Testing

- Procedure for measuring smoothness. Annual certification of profilograph shall be included (ITM 912)

Response to Test Results

- Corrective Action in response to mixture, temperature, and density tests

Certified Aggregate Producer

Certified HMA Producer

Certified Asphalt Supplier

Project Quality Control Plan